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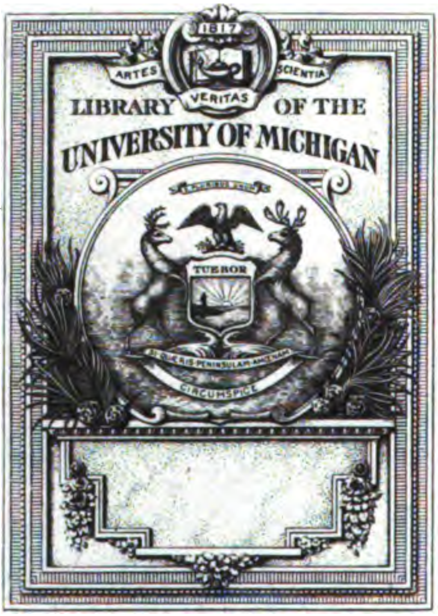

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REPORT

OF THE

CITY ENGINEER,

GRAND RAPIDS, MICH.

MAY 1ST, 1875

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REPORT

OF THE

CITY ENGINEER.

MAY 1ST, 1875.

OFFICE OF THE BOARD OF PUBLIC WORKS,
GRAND RAPIDS, MAY 1ST, 1875.

To the Hon. Board of Public Works of the City of Grand Rapids:

I herewith submit the following report of the Public Works which have been carried on under direction of the Board since its organization on the 1st day of April, 1873.

These works include the improvement of Streets and Alleys, the construction of Bridges, Public Buildings (except School Houses), and Sewers, the improvement of Parks, and the construction and maintenance of Water Works.

STREETS AND ALLEYS.

Since April 1st 1873 the following improvement of Streets and Alleys have been completed:

Streets Grading and Paving	1526	Lineal Feet.
Grading, Graveling and Paving Gutters	34994	" "
Grading and Graveling	23357	" "
Alleys Grading and Graveling	2186	" "
Grading	400	" "

Total length of improvements . . . . 62463 Lineal feet = 11 83-100 miles.

The total costs of these improvements was $134,766.19

Contracts have been made for the following improvements which are now in progress:

Streets Grading, Graveling and Paving Gutters	11503	Lineal Feet.
Grading and Graveling	7040	" "
Total	18543	Lineal feet = 3 51-100 miles.

The Streets paved were Monroe street, from the west line of Waterloo to the south line of Pearl; Ottawa street, from the north line of Monroe to the center of Pearl, and Pearl street from the center of Ottawa to the west line of Canal.

The pavement adopted for these Streets was what is known as the Chicago Free Pavement, which consists of pine blocks four inches thick and six inches long, set on end in rows running diagonally across the street, with one inch spaces between the rows, which are filled with gravel well rammed. The foundation is six inches or more of sand or fine gravel well rammed and shaped to the crown of the street.

The reasons for preferring this form of pavement were its cheapness, its simplicity, the rapidity with which it can be laid, and the ease with which it can be taken up and relaid, when necessary for laying or repairing sewers, gas or water pipes.

On each of these streets the slope of the gutter next to the side walk was paved with Joliet stone flagging, four inches thick and eighteen inches wide. The space between the rails of the street railroad on Monroe and Pearl streets was paved with cobble stones.

On Ottawa and Pearl streets the experiment was tried of paving only sixteen feet in width in the center with wood blocks, and the sides with cobble stones set in gravel. Care was taken to select stones of medium and as uniform size as practicable. This plan was adopted from motives of economy, the stone pavement costing less than half as much as the wood, and being practically indestructable, while the wood will probably not last more than ten years at most.

The result of this experiment will be watched with much interest, and if successful and satisfactory to the public, will probably be the solution of the pavement problem as far as all streets are concerned on which there is much travel. On a street 66 feet wide, with side walks 14 feet wide, the cost of such a pavement, with 16 feet of wood and the balance of stone, would at present prices, not exceed $3.70 per running foot. The center, which ninety per cent of the travel will naturally follow, will have the smoothness, elasticity, noiselessness, and comfort for horses, which are the characteristic qualities of wood pavements, and the cheaper and more durable material on the sides will compensate for the expense and want of durability, which are the great objections to the wood pavement.

The character of the cobble stone pavements now in use on some of our streets as Monroe, Bridge, Canal and Fulton, is not such as to make their extension popular, but with care in selecting stones of medium and uniform size, laying them on a solid foundation and ramming them thoroughly, the much abused cobble stone pavement can be made almost as smooth as wood, as the sample on Ionia street, from Fountain to Monroe, now witnesses.

Gravel has been and is still used here very largely for the improvement of streets, and where the material is good, and the travel moderate, it has done excellent service, but where there is much travel, it wears out rapidly, making the streets alternately muddy and dusty. Gravel of good quality is becoming very scarce within the city limits, and if arrangements could be made with some of the railroads to haul it in, it would be advisable for the city at an early day to purchase a gravel bed outside the limits. Otherwise we must be content with poor material or find a substitute. For streets of considerable travel an excellent material could be obtained by breaking up boulders which are too small for paving. They are very abundant here, and no better or more durable material for mecadamizing could be obtained anywhere, and if well rolled when first laid, it would make an excellent and durable road at about the same cost as boulder pavement or three times the cost of gravel. By using softer stone for the bottom, the cost could be considerably reduced. The labor of prisoners who are now a charge to the city, might be profitably employed in preparing this material, with the possible effect of diminishing the number of petty offences.

The total length of streets now opened in the city is about 129 miles, of which, counting those in progress as finished, are:

Graded and Paved with wood	0.15	Miles.
" " " " wood and stone	0.27	"
" " " " stone	3.25	"
Graded and Graveled with Paved Gutters	18.53	"
Graded and Graveled	28.69	"
Graded	8.12	"
Unimproved	70.20	"
Total	129.21	Miles.

The Common Council having ordered the establishment of the grades of all streets which have not been improved, levels have been taken, and profiles made as far as other duties would permit, but at our present rate of progress it will be the work of two or three years.

In establishing the grades of streets to be improved, it has been endeavored in all cases to fix them where they would be permanent, and thus encourage the building of permanent fences, the setting out of shade trees and the grading off of lots. This policy has increased in some instances the cost of the improvements, and given occasion to complaints and dissatisfaction, but it has been thought better to submit to these complaints, rather than by adopting a temporizing policy to repeat in the future the experience which has in the past been so frequent in this city and productive of so much expense and annoyance in the regrading of streets which had once been graded. on account of grades having been adopted which have since been found to be unsuitable.

The Board has also discouraged, as far as possible, the improvement of streets without paving the gutters, which in this city seems to be indispensable for keeping the streets in shape.

BRIDGES.

New stone piers and abutments have been constructed for the Leonard Street Bridge, at a cost of $2628.71. One of these was somewhat injured by the ice this spring, and it may be necessary to construct ice breakers to protect some or all of them.

At the request of the Council plans and specifications have been prepared for an iron bridge across Grand River, at the foot of Lyon street, to be used for market purposes, but no further action has been taken with reference to it. The plan contemplated ten deck spans of 57½ feet each and 100 feet in width, and two of 30 feet each and from 30 to 100 feet in width over the river, and an arch through truss of 100 feet span and 30 feet in width over the Canal. The estimated cost is $120,000.

The repairs of bridges belong properly to the Council, but under their instructions temporary repairs have been made on the Leonard Street Bridge at a cost of $661.96. The Council has also expended about $4000 on the same structure and comparatively small sums on the Bridge and Pearl Street Bridges.

BUILDINGS.

Engine Houses have been constructed on Barclay and Scribner streets, the former at a cost of $1180.53, the latter of $1070.00. Both are built on the same plan, of brick, 25 feet front by 40 feet in depth. The plans and specifications were prepared by John Grady, Architect, of this City.

The Board have adopted plans prepared by Charles H.

Marsh, of Rochester, N. Y., for the construction of a City Hall, estimated to cost $56,323.86, but the Council having taken no measures for providing the means, no work has been done. A building of some kind, in which all the public offices could be brought together, with adequate protection against fire for the records, is greatly needed.

PARKS.

Highland Park in the 4th Ward has been improved by fencing on the north, east and west sides, and by trimming up the trees and cutting out the underbrush and dead timber.

REPAIRS OF SEWERS.

The repairs of Sewers is not properly within the jurisdiction of the Board, but by direction of the Council the sum of $194.45 has been expended in the repair of Sewers and Catch-basins, and $283.00 in constructing two new Catch-basins on Ransom street and three on Fulton street.

SEWERS.

Since April 1st 1837 the following Sewers have been completed:

STREET.	FROM.	TO.	SIZE.	LENGTH.	COST.
			Inches.	Feet.	
Pearl	West Line Ionia st.	120 feet E. of Monroe	16x24	572	$1079 50
Fountain & Ottawa	East Line Division st.	North Gutter Monroe	24x36	700	1997 00
Lagrave	North Line Cherry st.	255 Feet N. of Oakes	24x36	720	3647 95
Maple & Lagrave	20 Feet E. of Sheldon	North Line Cherry	12	758	
Bronson	Alley E. of Division	Center Kent Alley	12–15and18	1175	3039 50
Erie	S. E. Cor. Canal & Bronson	Leitelt's Tail Race	12	297	570 60
Division	40 Feet S. of Bronson	40 Feet N. of Monroe	12 and 15	1724	2550 00
Court	80 Feet S. of Bridge	Center Valley	12	598	851 65
Waterloo	80 Feet S. of Mouroe	S. Gutter Fulton	18	960	2187 99
Ionia & Fulton	75 Feet S. of Monroe	W. Gutter Calder	15 and 18	982	2067 50
Kent & Alley, between Ottawa & Canal	N. Line Walbridge	Center Newberry	12	1325	1666 80
Alleys, between					
Kent & Ottawa	75 Feet N. of Lyon	Center Bronson	12	460	718 75
Almy & Calder	40 Feet N. of Cherry	Center Island	9 and 12	875	922 00
Mt. Vernon & Summer	160 Feet N. of Allen	Center Allen	9	193	196 90
Mt. Vernon & Court	40 Feet N. of Shawmut	Center Allen	9	393	460 00
Sheldon & Lagrave	20 Feet S. of Goodrich	Center Wealthy	12	350	460 00
Summit & Calder	N. Line Oakes	S. Gutter Fulton	12	797	1082 45

Total 12196 Lineal Feet, Costing $23,106 04

The first three of these Sewers are egg-shaped, and constructed, that in Pearl street of one course, and the others of two courses of hard-burnt brick, laid throughout in hydraulic cement mortar.

The total length of brick Sewers constructed was 1992 lineal feet.

The remainder, amounting to 10804 lineal feet, were constructed of Vitrified Fire Clay Pipe, circular and from nine to eighteen inches in diameter, with ring joints.

The Sewers in Court, Waterloo and Ionia and Fulton streets were constructed under contracts awarded by the Common Council and completed under the direction of the Board.

The average cost of these Sewers was $1.80½ per lineal foot, or, allowing one-sixth for street crossings, about $1.08 per lineal foot of property frontage on each side. On account of the great preponderance of small sewers in this list, this is much less than the average cost of our whole sewerage system.

The Sewers in Fountain and Ottawa and Pearl streets, amounting to 1272 lineal feet, were built to replace brick Sewers, which had been brought too near the surface for efficiency, by reason of the lowering of the grades of the streets. That in Erie street, and the greater portion of those in Bronson and Division streets, amounting to 2699 lineal feet, were built to replace old wooden sewers, which had either already fallen in or were about to fail, so that the actual addition to the sewerage system of the city has been but 8825 lineal feet. This addition has been almost entirely in small sewers designed to drain single streets or alleys. The only addition to the system of main sewers was the 720 lineal feet of brick sewer constructed in Lagrave street.

There is an urgent necessity for the extension of our main sewers, and the construction of new ones, in order to reach large sections of the City, which are wet and unhealthy, and which cannot now be drained for want of outlets. Long experience has shown that thorough drainage is one of the most efficient means of improving and preserving the health of cities, and the peculiar topography of our own city makes it especially necessary here.

I would recommend that early attention be given to the construction of the following main Sewers:

1st. The extension of the Spring Street Sewer, by way of Williams, Ionia, Prescott and Division Streets, Blakely Avenue, Center Street, the Alley running east and west in Block 1 of Blakely's Addition, Jefferson Avenue and Pleasant Street to Lafayette Street or Madison Avenue, with a branch in Wenham Avenue, from Prescott street to Lafayette Street. This would afford an outlet to a large section of the First and Third Wards, which now greatly needs drainage.

2nd. A main sewer commencing at Oakland Avenue, at the crossing of the Creek which runs through Grant's Addition, thence running east through private property to Grandville Avenue, thence by way of Prescott and Buchanan Streets, and the right of way of the Grand River Valley Railroad to Withey Street, with a branch up Withey Street to Lafayette Street:

This would enclose the Creek, which is fast becoming a nuisance, and drain the swamp on Grant's Addition, which is now unfit for human habitation.

3rd. A main sewer in Canal, Ottawa, Newberry (or Mason) and Kent Streets, from the Detroit and Milwaukee Railroad to Bridge Street. This is probably the only means by which that part of the City, north of Bridge Street and west of the Town Line can be effectually drained. This sewer would have to go under Coldbrook, and a gate could be arranged by which the waters of the Creek could be let into the sewer from time to time, in qualities sufficient to thoroughly cleanse its entire length, including its outlet, the Kent Alley Sewer, which is constantly causing trouble and expense by filling with sediment. The square turns in Kent Alley Sewer should also be taken out and easy curves substituted.

4th. A sewer in Plainfield avenue, from Quimby street to Coldbrook creek.

This sewer would cut off the large bodies of water which now in time of storms come down the ravines from the high grounds in the northeast part of the city, and flood the lands along the river.

5th. A sewer in the Turner Ditch, from Seventh street to Grand River.

The necessity of this sewer for the health of the wards west of the river is so apparent as to make comment unnecessary.

6th. It is desirable that provision should be made for the drainage of the territory bounded by Madison avenue, Division, Withey and Hall streets, by a main sewer in Highland avenue, Monson, Center, Greene, Division and Hall streets. The best and cheapest outlet for this drainage would be through Ionia street extended from Hall street to Rumsey Creek. Heretofore this has been impracticable from the fact of its being outside the city, but it is reported that the Legislature has just passed an act which will enable this difficulty to be overcome, by the co-operation of the city and the town of Wyoming.

The accompanying table gives a list of all the public sewers now in use in the city, with their lengths and sizes as nearly as can now be ascertained, the old records being very imperfect. From this list it appears that the total amount of sewerage is as follows:

Wooden Sewers	8,621 lineal feet	= 1 3341-5280	Miles
Brick "	28,922 " "	= 5 2522-5280	"
Clay Pipe "	23,198 " "	= 4 2078-5280	"
Cement Pipe"	2,680 " "	= 0 2680-5280	"
Total	63,421 lineal feet	= 12 miles 61 feet.	

Considerable of this amount, probably at least two miles, is of very little value, and will soon have to be rebuilt.

The old sewers of this city were badly designed in location, grades, shape, size, materials and construction. Sufficient attention was not given to the location of the main sewers on the most direct lines, and the result has been much unnecessary expenditure for construction and repairs, and needlessly long routes of drainage. This evil cannot now be remedied, but can be avoided in the location of future outlet sewers.

Some were built so near the surface that cellars cannot be drained into them, and these will have to be lowered, and even main sewers were built at so little depth that it is difficult now to get sufficient depth and fall for lateral sewers.

The worst defect of location was in making nearly all changes of direction and intersections of lateral with main sewers at right angles.

The checking of the velocity of the currents and consequent deposit of sediment, resulting from this violation of scientific principles has been a constant source of annoyance and expense, and will continue to be until this defect is corrected.

The old brick sewers were made with the lower part shaped like the letter V, with the brick work resting on a triangular block of timber, and usually the lower four or five courses were laid without mortar.

The V bottoms, with few exceptions, soon filled up with sediment to a considerable depth, diminishing the capacity of the sewer while the open joints greatly reduced its strength and, while they accomplished to some extent the object for which they were designed, of draining the subsoil water into the sewer, they also, when the subsoil was dry, had the opposite effect of draining the fluid contents out of the sewer, poisoning the subsoil, and leaving the solid contents to deposit and choke up the sewer. Quicksand is also liable to work through the joints and choke up the sewer.

Many of the early sewers were, from motives of economy, made of plank in box form, the form a bad one, and the material short-lived. Many of these plank sewers have already failed, and the rest are rapidly going to decay, with the single exception of one in Newberry street, which was covered on the top and sides with several inches of leached ashes, which has preserved the wood so effectually, that after more than ten years of service, it seems to be as sound as ever.

The street wash, including great quantities of sand from the bluffs, was admitted freely into the sewers, and rapidly filled up those that had not great inclinations or strong currents constantly running in them, while the almost total absence of manholes rendered the location or removal of deposits impossible without digging up the sewers at great expense and to the great annoyance and inconvenience of the public.

Parties tapping would knock holes into the sewers wherever it suited their convenience, leaving the debris in the bottom of the sewer. The want of rigid inspection gave opportunities to dishonest contractors to do careless work or use poor material, which were too often improved.

The sizes of the sewers were too often determined by guess work or the wishes of property owners without sufficient enquiry as to the duty they would eventually have to perform, and while some are necessarily large, others are likely to prove too small for the work which ought to fall upon them.

The writer has been laboring since he entered upon the duties of his office, to introduce a better system and with encouraging success, and he is greatly indebted to the Board of Public Works and to the several members of the Council before the Board was organized, for their steady co-operation and assistance.

Sewer Pipe was introduced in 1869 and has since been used almost exclusively for small sewers from nine to twenty-four inches in diameter, and for laterals to Catch-Basins and house drains. These pipes are mostly of Vitrified Fire Clay, circular in cross section, and made in sections two feet in length, connected by ring joints, which, we find, give more *honest* work in laying than the huf and spigot joint. For all sizes for which this material is suited, these pipes, with their smooth interior surfaces, form a much better channel for water than brick, even when most carefully laid.

Pipes manufactured of hydraulic cement and sand, have been used for laying about half a mile of sewers, and have so far given no trouble. They were somewhat cheaper than clay pipes, but the difficulty of obtaining good pipe, and of distinguishing good from bad, has led us to entirely abandon their use.

Brick sewers are now all made egg-shaped, with their horizontal and vertical diameters in the proportion of 2 to 3, a form which experience has shown to be the best for covered channels, conveying variable volumes of water.

All brick sewers, and the joints of pipe sewers are laid in hydraulic mortar, provision being made for the drainage of the subsoil, when necessary, as is frequently the case in this city, by leaving small openings through the upper part of brick sewers, and laying the upper half of the ring in pipe sewers without mortar, and protecting these openings from the admission of sand by a covering of straw or shavings. Any better method of accomplishing this object would be gladly adopted, and I am inclined to think that the use of hollow inverts of fire clay for brick sewers in wet ground would answer the purpose better, if they could be obtained.

Branches in pipe sewers, and slants of sewer pipe in brick sewers are inserted opposite every lot, so that hereafter breaking into a sewer for the purpose of tapping will be inexcusable.

All changes of direction and junctions are made with curves of as large radii as practicable. Man holes for access to the sewer and convenience in flushing are constructed at every change of direction, and at every cross street on straight lines, and sometimes at smaller intervals. On main sewers these man holes are located wherever lateral sewers are likely to come in, as these are the points where sediment is most likely to be deposited. Catch-Basins are constructed at all intersections of streets, and more frequently on steep streets, to receive the street wash, with traps to prevent the admission of solid matter into the sewers. The removal of the deposits from these basins involves some expense, but far less than its removal from the sewers. If the cleaning of these basins could be attended to more regularly and frequently than is now done, it would undoubtedly be conducive to the public health, and it may be necessary eventually to resort occasionally to the use of disinfectants.

The introduction of water works, will, as soon as the new pumping engines are completed, enable us by occasional flushing to keep our sewers much cleaner than they ever have been heretofore, with the result no doubt, of an improvement in the health of the city.

The writer has been engaged for several years, when not occupied by other duties, in studying a plan for a general system of sewerage for the whole city, and all new sewers that are ordered, are designed, as far as practicable, with reference to this system, the sizes being determined by the formula in use by the best hydraulic engineers, and it is hoped that none of the recent sewers, or of those that may hereafter be constructed, will ever have to be rebuilt by reason of defects in design, while the faithful performance of the inspection authorized by the Act creating the Board, will prevent the necessity for such re-construction arising from defective materials or workmanship.

PUBLIC SEWERS IN USE MAY 1st, 1875—1. BRICK SEWERS.

STREET.	FROM.	TO.	10-4x6-2	5x6	4x5	3x4	2x3	24x30	20x30	20x24	18x24	16x24	TOTAL
East Channel	s. line Pearl street	30 ft. south Ionia	358										358
Monroe and Pearl	e. line Division	east Channel			155	1604							1759
Spring, Oakes, etc	center Bartlett	inter. Ionia and Island			1460				333				1793
Pearl	e. gutter Division	e line Canal				63						981	1044
Justice	100 ft. s. of Monroe	sw, cor. Calder & Fulton										792	792
Walbridge	e. line Ionia.	e. gutter Ottawa							301				301
Lagrave	n. line Cherry	255 ft. n. of Oakes					720						720
Lyon	center Ransom	Tail Race				472	992		789				2253
Fountain and Ottawa	center Ransom	n. gutter Monroe					700	786					1486
Kent Alley	63 ft. s. of Hastings	center Lyon				1257			487				1744
Hastings and Canal	e. line Ionia	50 ft. n. Hastings								1060			1060
Ottawa	n. line Walbridge	250 ft. s. Trowbridge									2726		2726
Bridge east	w. line Ionia	center Kent alley				110					539		649
Ransom and Fulton	s. line Fountain	center Jefferson av								972			972
Fulton and Jefferson	e. line Lafayette	Washington street								1313			1313
Bostwick	423 ft. n. of Fountain	center Fountain								456			456
Washington, Sheldon, Island, Calder & Fulton	e. line Madison ave	w. line Waterloo		1164		1611			1404				4179
Lafayette	50 s. of Fulton	center Washingt'n									579		579
Luce	center Cherry	center Washingt'n						756					756
Fourth	w. line Stocking	Turner Ditch									1733		1733
Jefferson and Second	n. line Third	Turner Ditch									834		834
Summer	150 ft n. of Shawmut	center Bowery										1015	1015
R.E. Wood's l'd, Fulton	393 ft. w. of Union	w. line College 263 ft. s. of Fulton					100		300				400
Total			358	1164	1615	5117	2512	1542	3614	3801	6411	2788	28922

The first of these Sewers is a semi-circular brick arch with stone abutments resting on a plank foundation, the next six are built on the new system, the following three partly on the old and partly on the new. The rest are all built on the old system.

2. VITRIFIED FIRE CLAY PIPE SEWERS.

STREET.	FROM.	TO.	18''	15''	12''	9''	TOTAL.
Ionia & Fulton	75 Feet S. of Monroe	S. W. Cor. Calder & Fulton	482	500			982
Division	N. Line Withey	Center Blakely	1540				1540
"	N. Line Maple	Center Cherry			491		491
"	25 Feet N. of Cherry	Center Island		869			869
"	40 Feet No. of Monroe	S. Line Pearl		205	703		908
"	N. Line Pearl	40 Feet S. of Bronson			816		816
Cherry	W. Line Division	Center Spring			318		318
Waterloo	80 Feet S. of Monroe	S. Gutter Fulton	960				960
Maple & Lagrave	25 Feet E. of Sheldon	N. Line Cherry			758		758
Erie	S. E. Cor. Bronson & Canal	Leitelt's Tail Race			297		297
Bronson	Alley E. of Division	Center Kent Alley	129	575	473		1177
Kent & Alley E. of Canal	N. Line Walbridge	Center Newberry			1335		1325
Private Property	Inters. Wealthy & Cass	E. Line Lafayette		440			440
Fifth	E. Line Stocking	Turner Ditch			2030		2030
Third	W. Line Scribner	Turner Ditch				741	741
"	E. Line Scribner	Powers' Canal				307	307
Bridge West	W. Line Straight	Turner Ditch			1795		1795
" "	186 Feet E. of Fremont	Lane Avenue			327	250	577
Allen	W. Line Winter St.	Powers' Tail Race	1218				1218
Court	80 Feet S. of Bridge St.	Center Valley			598		598
West Division and Bowery	N. Gutter Sibley	Turner Ditch		1440			1440
Alley between Kent & Ottawa	S. Line Trowbridge	Center Hastings			543		543
" " "	75 Feet N. of Lyon	Center Bronson			460		460
Almy & Calder	40 Feet N. of Cherry	Center Island			449	426	875
Summit & Calder	N. Line Oakes	S. Gutter Fulton			797		797
Alley between Sheldon & Lagrave	20 Feet S. of Goodrich	Center Wealthy			350		350
Court & Mt. Vernon	40 Feet N. of Shawmut	Center Allen				393	393
Summer & Mt. Vernon	160 Feet N. of Allen	Center Allen				193	193
	Total		4329	4029	12530	2310	23198

3. CEMENT PIPE SEWERS.

STREET.	FROM.	TO.	18''	12''	9''	8''	TOTAL.
Taylor	12 Feet N. of Leonard	20 Feet No. of S. Line Quimby	96	1175	513		1784
Ionia & Walbridge	290 Feet N. of Walbridge	50 Feet W. of Ionia				370	370
Alley between Division and Bostwick	S. Line Bronson	Center Lyon		526			526
	Total		96	1701	513	307	2680

4. WOODEN SEWERS.

STREET.	FROM.	TO.	3'x4'	18''x24''	18''x18''	12''x18''	12''x12''	TOTAL.
Newberry & Canal	W. Line Ionia	50 Feet N. of Hastings,	2428					2428
Ionia	N. Line Fountain	Center Bronson		1153				1153
Wealthy, Sheldon & Wenham.	W. Line Cass	W. Line Division	1900					1900
Jefferson Ave	150 Feet N. of Blakely	Center Wealthy			850			850
Second St	W. Line Scribner	Turner Ditch				834		834
Alley between Ottawa and Ionia	50 Feet S. of Bridge	Center Bronson					507	507
" " "	50 Feet N. of Lyon	Center Bronson					467	467
Ottawa and Kent	75 Feet S. of Bridge	Center Bronson		482				482
	Total		4328	1635	850	834	974	8621

Total length of Sewers 63421 feet — 12 miles, 61 feet.

FIELD AND OFFICE WORK.

The ordinary routine of duty of the City Engineer and his Assistants includes the taking of levels and measurements, and preparing profiles, plans, specifications and estimates of cost and quantities for all improvements ordered by the Council, the setting of grade stakes, and preparation of occasional and final estimates for contractors, surveys and descriptions of lands to be taken for street openings, and the fixing of disputed street lines. The construction of the Water Works has greatly added to the ordinary work during the past two years, and compelled the employment of an increased force.

In addition to the above work a complete set of maps has been made of the whole city, on which the street numbers of every lot are shown. This work was made necessary by the action of the Council in adopting a new system of numbering when the system of free delivery of the mails was introduced. These maps are kept on file at the office for the inspection of all concerned.

The set of Ward maps which is kept on file has been kept complete by the addition of the plats of all new sub-divisions as fast as made. The power conferred upon the Board to control these plats has had a good effect in preventing the laying out of narrow streets and such as would not correspond with streets already laid out. It would be well if this authority could be extended as it is in Detroit, over such territory lying outside the City limits, as is likely at some future day to be included in the City.

A set of Maps is being prepared which will show the location of all the water mains, hydrants, valves and branches, and all taps that have been or may hereafter be made. These maps are made on a large scale in sheets, which, when finished, can be bound in Atlas form for preservation and convenience of reference.

The profiles and grades of all streets and alleys that have been improved, and sewers that have been constructed since the organization of the Board, with the location of all branches for tapping the sewers, have been recorded in record books manufactured expressly for the City.

Whenever time and opportunity would permit, stakes have been set to mark the intersection of streets, to govern the survey of lots. Much confusion exists in several of the old plats in consequence of errors in the original surveys, and the different methods that have been adopted by different surveyors to rectify these errors. It is very desirable that the Common Council should exercise the authority conferred on them by the charter, by taking measures before land becomes more valuable, to have accurate surveys of these plats made, and the streets fixed by permanent monuments, so that this confusion and the consequent litigation may be avoided in future.

SUMMARY OF WORK DONE.

In the accompanying table will be found a list of all the improvements made under the direction of the Board, except Water Works, with the name of the Contractor and the cost for Construction and for Engineering, Printing and Assessment. From this table we deduce the following summary:

Total Length of Streets Improved	59,877	Feet.
" " " Alleys "	2,586	"
" " " Sewers Built	12,896	"

Total cost of Improvements let by Council and completed by Board:

Sewers	$ 5,107 14	
Grading	137 30	
Grading and Graveling	36,522 56	
Grading, Graveling and Sewering	7,575 63	
Grading, Graveling and Paving Gutters	24,234 56	$73,577 19

Total cost of Improvements let and completed by Board:

Sewers	$16,354 03	
Grading and Paving	10,147 93	
Grading, Graveling and Paving Gutters	52,533 58	
Grading, Graveling and Sewering	2,571 45	
Grading and Graveling	2,492 05	
Buildings and Miscellaneous	6,312 55	$90,411 59

Total cost of completed work	$163,988 78
Add payments made on work in progress	27,816 31
" Cost of Water Works Construction	274,523 10
" " " " " Operation	6,666 09
Total expended under Direction of the Board	$472,994 28

IMPROVEMENTS CONDUCTED BY BOARD OF PUBLIC WORKS.

APRIL 1, 1873, TO MAY 1, 1875.

1. IMPROVEMENTS CONTRACTED BY COUNCIL, COMPLETED BY BOARD.

GRADING GRAVELING AND SEWERING.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	COST.		
					CONSTRUCTION.	ENGINEERING, ASSESSMENT AND PRINTING.	TOTAL.
1. Taylor St.	Leonard St.	North Limits.	2600	Gorman & Gill	$5818 70	$261 40	$6080 10
2. Walbridge St.	Ionia St.	Canal St.	620	Joel Collins	1398 28	106 25	1495 53
					$7207 98	$367 65	$7575 63

1. Sewer from 12 feet North of Leonard to 20 feet North of South Line Quimby.
2. Sewer from E. Line Ionia to E. Gutter Ottawa. Gutters paved Ionia to Ottawa.

GRADING AND GRAVELING.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	CONSTRUCTION.	ENGINEERING, ASSESSMENT AND PRINTING.	TOTAL.
3. Livingston St.	Bridge St.	Newberry St.	2266	Carl Utes.	$ 2529 00	$163 60	$ 2692 60
4. Ionia St.	Bridge St.	Coldbrook St.	4209	Joel Collins.	11328 16	400 70	11728 86
5. Mason St.	Ionia St.	Canal St.	792	" "	741 74	99 55	841 29
6. Leonard St.	Front St.	West Limits.	5977	Hunter & Stack	8135 34	419 93	8555 27
7. Court St.	Bridge St.	Front St.	1343	David Miller.	3476 00	147 95	2623 95
8. Walker Ave.	Seventh St.	West Limits.	2293	Smith & Wells	3158 90	116 90	3275 80
9. Grandville Ave.	Summit St.	South Limits.	6650	Frank Cane.	5550 54	254 25	5804 79
			23530		$34919 68	$1602 88	$36522 56

3. Gutters paved from Bridge st. to Hastings st., Roadway paved from Bridge St., 175 ft. north.
4. Gutters paved from Bridge St. to Newberry st.
5. Gutters paved from Ionia to Ottawa st.
6. Masonry Culvert constructed at Pine st.
7. Masonry Culvert at Valley St.
8. Masonry Culvert at Powers st.
9. Stone Culvert at Prescott st., Gutters paved from Prescott to Fourth Ave.

GRADING.

Alley between Spring & Ionia	Oakes St	Cherry St	400	E. S. Hulbert	$114 40	$22 90	$137 30

SEWERS.

Ionia & Fulton	75 Ft. S. of Monroe	W. Gutter Calder	982	E. S. Hulbert	$1936 00	$131 50	$2067 50
Waterloo	80 Ft. S. of Monroe	S. Gutter Fulton	960	Joel Collins	2093 79	94 20	2187 99
Court	80 Ft. S. of Bridge	Center Valley	598	Charles Prange	779 00	72 65	851 65
			2540		$4808 79	$298 35	$5107 14

GRADING, GRAVELING AND PAVING GUTTERS.

Allen St	Front St	Winter St	1162	Charles Prange	$ 1173 00	$122 20	$ 1295 20
Carrier St	Plainfield Ave	325 Feet E	325	Patrick Gill	1555 00	154 40	1709 40
Cherry St	Madison Ave	East Limits	2641	N.W. Northrup	5345 00	298 95	5643 95
Paris Ave	Cherry St	Wealthy Ave	1269	Prange & Liv'n	2052 85	117 15	2170 00
Prospect St	Bridge St	Fountain St	1738	Joel Collins	2446 54	165 63	2612 17
Summit St	Fulton St	Wealthy Ave	2565	G. A. McDonell	10476 34	327 50	10803 84
			9699		$23048 73	$1185 83	$24234 56

2. IMPROVEMENTS CONTRACTED AND COMPLETED BY BOARD.

SEWERS.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	COST. CONSTRUCTION.	COST. ENGINEERING, ASSESSMENT AND PRINTING.	COST. TOTAL.
Maple and Lagrave	20 ft. E. of Sheldon	255 Ft. N. of Oakes	1478	Joel Collins	$3505 00	$142 95	$ 3647 95
Bronson	Alley E. of Division	Kent Alley	1177	" "	2797 30	242 20	3039 50
Erie	Canal St	Tail Race	297	" "	495 10	75 50	570 60
Fountain & Ottawa	E. Line Division	Monroe St	700	" "	1806 00	191 00	1997 00
Pearl	W. Line Ionia	120 ft. E. of Monroe	572	" "	972 50	107 00	1079 50
Division	40 ft. S. of Bronson	40 ft. N. of Monroe	1519	" "	2406 60	144 90	2551 50
Kent St. & Alley	N. Line Walbridge	Center Newberry	1325	" "	1576 00	90 80	1666 80
Alley between Kent & Ottawa	75 ft. N. of Lyon	Center Bronson	460	" "	679 00	39 75	718 75
Alley between Summit & Calder	N. Line Oakes St	Fulton St	797	Marcus Powers	1007 75	74 70	1082 45
			8325		$15245 25	$1108 80	$16354 05

GRADING AND PAVING.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	COST. CONSTRUCTION.	COST. ENGINEERING, ASSESSMENT AND PRINTING.	COST. TOTAL.
Monroe	Waterloo	Pearl	336	James B. Smith	$3983 73	$153 20	$ 4136 93
Pearl	Ottawa	W. Side Canal	594	" "	3535 30	136 80	3672 10
Ottawa	Monroe	Pearl	421	" "	2168 85	170 05	2338 90
			1351		$9687 88	$460 05	$10147 93

GRADING, GRAVELING AND PAVING GUTTERS.

Louis	Fulton St	Grand River	1640	Carl Utes	$ 6779 31	$204 40	$6983 71
Jackson	West Division	Marion	3260	" "	10124 75	198 60	10323 35
Prospect	Washington	State	421	Chas. B. Smith	686 00	78 70	714 70
Bronson	Prospect	Union	1545	T. C. Brooks	3467 05	158 04	3625 09
Broadway	Bridge	Seventh	2557	Smith & Wells	3548 35	149 40	3697 75
Waterloo	Monroe	Fulton	1070	C. Prange	4227 07	249 94	4477 01
Seward	Bridge	Fourth	1504	O. B. Gibson	1300 00	93 55	1393 55
Union	Fulton	Wealthy	2586	Utes, Prange & Livingston	6457 00	171 95	6628 95
Lake Ave	Fulton	East Limits	1508	" "	2618 00	105 20	2723 20
College Ave	Bridge	Fulton	2558	Joel Collins	5585 00	202 75	5787 75
" "	Fulton	Cherry	1256	" "	2893 75	123 00	3016 75
Prospect St	Cherry	Wealthy Ave	1260	Utes, Prange & Livingston	3076 67	85 10	3161 77
			21165		$50712 95	$1820 63	$52533 58

GRADING, GRAVELING AND SEWERING.

Alley between Almy & Calder	Island	Cherry	866	Carl Utes	$1115 00	$94 40	$1209 40
Court & Mt. Vernon	Shawmut	Allen	400	Charles Prange	509 50	68 20	577 70
Sheldon & Lagrave	Goodrich	Wealthy	320	Utes, Prange & Livingston	715 00	69 35	784 35
Summer & Mt Ver'n	Allen	200 feet North	200	Done by property owners			
			1786		$2339 50	$231 95	$2571 45

GRADING AND GRAVELING.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	COST.		
					CONSTRUCTION.	ENGINEERING, ASSESSMENT AND PRINTING.	TOTAL.
Summer St	Shawmut	West Fulton	866	Phœnix Manufacturing Co.	$1809 90	$102 75	$1912 65
Alley between Spring & Ionia	Island	Oakes	400	Charles Prange	493 00	86 40	579 40
			1312		$2302 90	$189 15	$2492 05

BUILDINGS AND MISCELLANEOUS.

IMPROVEMENT.	CONTRACTOR.	COST.
Engine House in Fourth Ward	Carey & Jones	$1180 53
" " " Sixth "	Sheridan & Boland	1070 00
Piers of Leonard Street Bridge	James Higgins	2628 87
Improvement of Highland Park	B. R. Wheeler	293 74
Repairs of Leonard Street Bridge		661 96
Repairs of Sewers and Catch-Basins		194 45
Building new Catch-Basins		283 00
		$6312 55

3. IMPROVEMENTS CONTRACTED BY BOARD, NOW IN PROGRESS.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	IMPROVEMENT.	ESTIMATED COST.
Carrier St.	235 ft. E. of Plainfield Ave.	Union St.	2965	Patrick Gill	Grading & Graveling	$2500
Straight St.	Butterworth Ave.	Bridge St.	4075	Thomas & Enwright	" " "	4300
Clancy St.	Fairbanks St.	Cedar St.	2110	Utes & Livingston	Grading, Graveling & Paving Gutters	6600
Bostwick St.	Bridge St.	Lyon St.	1076	Joel Collins	Grading, Graveling & Paving Gutters	3000
Waterloo St.	Cherry St.	Wealthy Ave.	1702	F. B. Gilbett	Grading, Graveling & Paving Gutters	7800
Madison Ave.	Cherry St.	South Limits	6615	Patrick Grady	Grading, Graveling & Paving Gutters	14300
						$38500

On these improvements payments have been made on estimates to the amount of $27,816.31.

WATER WORKS.

Until the year 1849 the people of Grand Rapids depended entirely on wells, cisterns or springs for their supply of water for all purposes, and a large majority still have no other dependence. In that year the Grand Rapids Hydraulic Company was organized for the purpose of utilizing some large springs issuing from the hill side, for supplying water for domestic purposes.

The accompanying sketch of the history and operations of this Company, from the hand of Joseph Penney, Esq., will be of much interest to our citizens as a part of the history of the City.

The water furnished by this Company is of excellent quality, and has been largely used in the lower portions of the city, but, being conveyed in pump logs, not capable of sustaining heavy pressure, was of no service for protection against fire, except so far as it could be used for filling the public reservoirs, which, with the river and canals, were the principal dependence for supplying fire engines. The inadequacy of this supply lead to many destructive fires, which finally satisfied our people of the necessity of some better means of protection, and after a discussion which lasted several years between the advocates of different sources of supply, and of the Reservoir and Holly Systems, and investigations and reports on both points from J. L. Pillsbury, Esq., and Peter Hogan, Esq., Hydraulic Engineers, on the 30th day of July, 1873, the people almost unanimously voted to raise $250,000 by loan, for the construction of Water Works on the Reservoir System, with Carrier Creek, Coldbrook and Lamberton Lake successively as sources of supply.

In consequence of the difficulty of negotiating bonds, arising from the financial panic, nothing could be done until the 9th day of October following, when the Board of Public Works received bids for furnishing and laying about two miles of cast iron pipe, with the necessary hydrants and valves. which was as much as the means then in hand would pay for. The following is a schedule of the bids received:

	J. Flower & Bros.	H. A. Branch.	C. Peterson.	W. R. Coats	Newport Manufact'ng Co.
12 Inch Pipe......	$3.60 per lin. foot	$ 3.75	$ 3.46	$104 per ton	....
10 " "	2.68 " " "	2.81	2.75	" " "	....
4 " "	1.15 " " "	1.20	1.00	" " "	....
Single Hydrants	42.00 " " "	58.50	63.00	55.00.........	$40, not incl'g setting.
Gate "	....	....	....	....	45, not incl'g setting.
12 Inch Valves..	83.00, incl. boxes	110.00	80.00	116.25.........	72, not incl'g setting.
10 " "	58.00, " "	90.00	60.00	96.25.........	55, not incl'g setting.
Special Castings	....	6¼c. p. lb	....	....	....

The contract was awarded on the 14th of October to Charles Peterson of Lockport, N. Y., who immediately commenced work and completed it towards the last of December. His work was well done and has given entire satisfaction. Under this contract the work done included the laying of 9575¾ lineal feet of pipe and the setting of 20 Ludlow Hydrants and 11 Ludlow Valves. Of the four inch pipe 129 feet was laid for the purpose of connecting with the private reservoir of C. C. Comstock, Esq., and with the pumps of A. Leitelt Bros. & Co., Butterworth & Lowe and Nelson, Matter & Co., in order to make the work which had been done available for fire protection during the winter, and 283 feet of six inch pipe was for branches to hydrants.

The following copy of the final account with Mr. Peterson will show more fully the character of the work, and will be of interest to those who desire to know how the money of the public has been expended:

5615⅙	Lineal feet, 12 inch pipe..........	@	$ 3.36......	$18,866 96
2649½	" " 10 " "	@	2.68......	7,108 70
727¾	" " 6 " "	@	1.75......	1,273 56
580⅓	" " 4 " "	@	1.00......	580 33
20	Double Hydrants..................	@	76.00......	1,520 00
5	12 Inch Stop Valves..............	@	85.00......	425 00
3	10 " " "	@	65.00......	195 00
1	6 " " "	@	50.00......	50 00

2	4 Inch Stop Valves	@	$32.66	$65 00
1	4 " " " not set			25 00
16701	lbs Special Castings	@	00.07½	1,252 87
277	Cubic Yards Extra Excavation	@	00.90	249 30
11105	lbs Iron Pipe, not laid	@	69.00 p. ton	383 09
11327½	" " " " "	@	45.00 " "	254 70
1248	" Special Castings, not laid	@	00.05½	68 64
Setting Safety Valve				31 83
	Total			$32,350 00

The pipe "not laid" included in this account was such as was left over on the completion of the contract, and was purchased by the Board for use in future repairs and extensions. Some of it has been so used and some is still on hand.

No further work was done until April 14th, 1874, when bids were received for furnishing and laying about ten miles more of pipe. Accompanying this is a schedule of the bids received.

After a careful comparison of the bids, the contract was awarded on the 18th of April to Thomas B. Farrington, who had associated with himself Mr. H. A. Branch, and the firm immediately commenced work, and completed their contract in the following November. The laying of the pipe was done under the immediate supervision of Newton T. Smith, Assistant Engineer, as Inspector, who faithfully discharged the duties of his office.

Mr. Elihu Smith was employed for a time at the Manufactory at Bay City to inspect the pipe before shipment, at the joint expense of the contractors and the city.

SCHEDULE OF BIDS FOR WATER PIPE, APRIL 14th, 1874.

	John F. Ward. Cast Iron.	H. A. Branch. Cast Iron.	C. Peterson. Cast Iron.	W. R. Coates. Cast Iron.	Jas. B. Smith. Cast Iron.	J. B. Flower & T. Smith. Cast Iron.	Lake Shore Foundry Works. Cast Iron.	Pat. Water & Gas Pipe Co. Cement.	American Wat. & Gas Pipe Co. Cement.	Thos. B. Farrington. Wyckoff Wood
20 inch Pipe.........	$ 5.26 p. foot	$ 6.00	$ 5.25	$ 5.30	$ 5.50	$ 5.53	$ 5.38	$ 4.60	$ 4.84	$ 5.28 iron.
16 " "	3.60	4.21	3.65	3.60	3.85	3.85	3.80	3.36	3.00	3 63 iron. 2.69 wood.
14 " "	3.11	3.37	3.15	3.25	3.35	2.97	3.28	2.74	2.50	3.27 iron. 2.37 wood.
12 " "	2.50	2.76	2.54	2.49	2.55	2.52	3.18	2.24	2.18	2.53 iron. 1.81 wood.
10 " "	1.95	1.93	1.92	1.90	1.95	1.95	2.05	1.88	1.66	1.59 wood.
8 " "	1.57	1.75	1.57	1.57	1.60	1.65	1.78	1.43	1.29	1.27
6 " "	1.16	1.22	1.18	1.18	1.18	1.23	1.37	1.17	1.06	.99
4 " "	.76	.89	.77	.82	.79	.85	.90	.83	.85	.66
20 " Valves......	400.00	265.00	350.00	250 00	375 00	244.00	349.00	300.00	225.00	265.00
16 " "	256.00	195.00	250.00	175.00	175.00	165.00	240.00	175.00	175.00	195.00
14 " "	196.00	145.00	200.00	135.00	165.00	124.00	175.00	150.00	122.00	144 00
12 " "	144.00	99.00	150.00	85.00	90.00	79.00	118.50	96.00	78.00	99.00
10 " "	100.00	79.00	85.00	61.00	80.00	55.00	85.00	80.00	65.00	79.00
8 " "	64,00	65.00	60.00	51.00	50.00	44.00	68.00	64.00	52.00	65.00
6 " "	36.00	45.00	40.00	40.00	35.00	34.00	53.00	48.00	39.00	45.00
4 " "	16.00	35.00	28.00	25.00	25.00	23.00	32.00	32.00	20.00	35.00
Hydrants Single...	55.00	45.00 Ludlow 50.00 Cregier	57.00	50.00	50 00	40.00	65.00	30.00	50.00	46.00
" Double..	75.00	55.00 Ludlow 85.00 Cregier	64.00	55.00	70 00	42.00	75.00	55.00	56.00	85.00 Cregier 95.00 Lowry.
Special Castings...	00.04½ per ℔	.04	00.06	00.04⅞	00.05	00.03½	00.05½	00.04½	00.04½	4 cents.
Extra Excavation	$1.00 per cb. yd	.40	00.75	00.30	00.50	00.50	00.35	00.50	00.40	45 "
Rock under Water	$40.00 " " "	....	40.00	....	....	....	35.00	....	50.00	....
12 Inch Pipe under River..........	$13.00 per foot.	....	13.00	....	28.00	10 00	13.00	12.00	14.00	....

Schickle & Harrison $59 per gross ton. Wm. Smith & Sons $54.88 per gross ton for 4, 6 and 8 inch; $56,00 for 10, 12, 16 and 20 inch. Pipe under River. George C. Morgan, 12 inch iron $9 per foot. T. B. Farrington, 10 inch wood under Bridge $5.59, on Bridge $3.59. Cregier, Clark & Co., Single Hydrants $45. Double Hydrants $80. 12 Inch Valves $95. 16 Inch Valves $225.

The workmanship of the Hydrants furnished was not entirely satisfactory to the Board, and a balance of $13,758.85 now due the Contractor remains unpaid, until they can have time and suitable weather to correct this defect. Of this amount $10,000 is to be retained in the hands of the City as collateral to the bond given by the Contractors to keep the pipe in order five years.

Following is the final account of the work done by Farrington & Branch:

455.84	Lineal Feet 20 inch Iron Pipe	@ $ 5.28	$ 2,406.83
131.00	" " 16 " " "	@ 3.63	475.53
2,408.91	" " 16 " Wood "	@ 2.69	6,479.97
4,438.05	" " 14 " " " Light	@ 2.17	9,630.57
13,358.18	" " 12 " " "	@ 1.81	24,178.31
972.32	" " 12 " " " Light	@ 1.65	1,604.23
4,176.55	" " 10 " " "	@ 1.59	6,640.71
120.00	" " 10 " " " Light	@ 1.45	174.00
8,820.82	" " 8 " " "	@ 1.27	11,202.44
1,142.08	" " 8 " " " Light	@ 1.16	1,324.81
13,603.60	" " 6 " " "	@ 0.99	13,467.56
747.00	" " 6 " " "on Br'ge	@ 0.90	672.80
12.55	" " 6 " Iron "	@ 1.22	15.06
6,383.35	" " 4 " Wood "	@ 0.66	4,213.01
4	20 inch Valves	@ 265.00	1,060.00
4	16 " "	@ 195.00	780.00
2	14 " "	@ 145.00	290.00
17	12 " "	@ 99.00	1,683.00
6	10 " "	@ 79.00	474.00
8	8 " "	@ 65.00	520.00
16	6 " "	@ 45.00	720.00
5	4 " "	@ 35.00	175.00
117	Lowry Hydrants	@ 95.00	11,115.00
1	Ludlow Hydrant	@ 57.00	57.00
19	Hydrant Bases	@ 25.00	475.00
1	" Head		100.00
159	Plugs	@ 1.50	238.00
40247	lbs Special Castings	@ 0.04	1,609.88
1844	Cubic Yards Extra Excavation	@ 0.45	829.80
72	Square " " Paving	@ 0.20	14.40
2	Extra Valve Boxes	@ 1.00	2.00
Total			$102,628.91

LOCATION OF PIPES.

In locating the pipes which have been laid under these two contracts, the selection of streets has been made with a view, not so much to obtaining a large revenue from the domestic use of the water, as to the protection from fire of as much as possible of the most valuable property in the City, especially the manufacturing establishments, which are the most important contributors to the city's prosperity.

This object has now been mainly accomplished and in future extensions of the pipe system revenue will be the most important consideration.

In carrying out this design it will be observed that a much larger proportion of the pipes that have been laid are of larger sizes than is usual, and the cost has been proportionally great. In future extensions the proportion of large mains, and consequently the average cost will be much smaller. The sizes of the pipes have been determined with reference to a general plan, which has been prepared with great care, and which, it is thought, can be extended, as needed, to the entire city, without the necessity of ever replacing any of the pipes that have been laid, with larger sizes, a necessity which has been an occasion of great expense to most of our American cities. This general plan includes a number of large mains branching out in all directions from the reservoir, and intersected at moderate intervals by cross mains of smaller size, while the intermediate spaces are filled up by a net-work of mains of still smaller size, but of comparatively short lengths.

KIND OF PIPE.

When the first two miles of pipe was laid in the Fall of 1873, the season was so far advanced that there was no time for investigation as to the kind of material to be used, and cast iron was adopted in accordance with the general usage in this country. The iron pipes laid by Mr. Peterson, as well as those since laid by Farrington & Branch, were all coated inside and out with coal-tar prepared by Dr. Angus Smith's process, to protect them from rust, and the fact that but two breaks have occurred since the two miles were laid, indicates that the pipe is of good quality, and was laid with care.

When ten miles more were to be laid, it became a question whether some other kind of pipe could be used, which would be more economical and equally serviceable. To determine this question proposals were invited for Cast Iron, Wrought Iron—cement lined, and Wood Pipe, and enquiries were made to ascertain as far as practicable, the experience of other cities which had used the last two kinds of pipe. When the bids were opened, it appeared that a large saving in cost could be effected by adopting either the Wrought Iron—cement lined, or the Wood Pipe, the advantage in this respect being with the wood. After careful consideration the Board determined to adopt the Wood pipe for all sizes up to sixteen inches, which was the largest that the manufacturers would venture to make, this city being the first in which any over twelve inches in diameter has been used. In coming to this decision the Board was governed by the following considerations:

Cast Iron, as a material for water pipes, is subject to two objections.

1st. Its liability to corrosion and the formation of tubercles under the action of soft water.

Formerly this was certainly a serious objection and Hydraulic Engineers who advocate other kinds of pipe always refer to instances which occurred at Boston, Torquay and some other places, where the capacity of the pipes was considerably reduced by the formation of tubercles, but the general introduction of Dr. Angus Smith's process seems to have proved an effective remedy for this difficulty, and the fact that the water here is mostly hard, which has little effect on cast iron, made this objection one of but little force with us.

2nd. Its liability to fracture when subjected to blows, such as occur whenever a hydrant is suddenly closed, or in any other way a sudden check is given to the moving column of water.

When such a fracture occurs it can only be repaired by cutting out a piece of the broken pipe and sleeving in another.

Engineers have tried to remedy this objection by requiring unusual care in the selection of material and casting of the pipes, and by giving them a greater thickness (and consequently weight and cost) than is necessary to withstand the static pressure of the water. That this remedy is not always effectual, and that the difficulty is one that cannot be entirely obviated, except at unreasonable expense, is evident from the long annual bill of repairs to be found in the reports of every city in which cast iron pipe is generally used.

The hope of saving this large annual expense, and the annoyance to the public of having the streets frequently torn up for repairs, was a sufficient inducement to give careful consideration to the claims of any other material which promised to be free from this defect.

The Wrought Iron pipe, lined with cement, and covered on the outside, when laid, with the same material, had been highly recommended by both Mr. Pillsbury and Mr. Hogan, the prices bid were much lower than for cast iron, and the experience of Charlestown, New Bedford, Hartford, New Haven, Jersey City and other cities where it had been laid, appeared to be favorable. It seems to be free from the peculiar defects of cast iron, and to make a safe, economical and durable water pipe, so long as the lining and covering can be kept *unbroken.* A serious objection to its use in bad soils is the liability of the lining or covering to crack from unequal settlement. When this occurs the water gets access to the wrought iron and rapidly destroys it. Several instances where this pipe had failed from this cause were brought to the knowledge of the Board, and finally lead to its rejection, as the character of the soil in many parts of this city is such as to expose the pipe to unusual hazard.

The Wyckoff Patent Wood Pipe which was adopted by the Board, is manufactured from sound white pine logs, from which all bark and sap is removed, and of such size that when bored the shell is about three inches thick. The boring is done by peculiar patented augers. The pipe is strengthened by a band of wrought iron manufactured from the best Lake Superior ores, about one inch in width, and of a thickness corresponding with the pressure. The band is put on spirally with such force as to sink its entire thickness into the wood, and the ends are wrapped three times around the pipe and firmly secured with copper rivets. In the pipe laid here number 12 iron was used on the lower levels, and number 14 on the upper levels, where so great strength was not required, and the spirals were about one inch apart, leaving space between them for tapping. The band while being wrapped is passed through a hot bath of coal tar and asphaltum, and the whole outside of the pipe is covered with the same preparation. The joint is formed by a thimble of the same material as the pipe, about six inches long and one inch thick, which fits equally into sockets in the ends of two adjoining pipes. These thimbles should be thoroughly seasoned so that by swelling when wet, they may make a perfectly water tight joint.

Some suggestions have been made towards the improvement of this joint, as well as some other points in the manufacture of the pipe, which it may be well to adopt if more of this pipe should be laid.

The pipe is constructed on the theory that the required strength is furnished by the wrought iron band so long as it is kept from rusting; that this is effected by the covering of coal tar and asphalt, a substance not liable, when properly prepared, to fracture by unequal settlement; that the outside of the wood pipe is protected from decay by the same means, and the inside by the constant presence of water; and that the elasticity of the wrought iron and wood will enable the pipe to resist, without injury, the effect of the water-ram.

Our experience has been too short to test the truth of this theory, but we have abundant evidence from other cities, where the pipe has been in use for twelve years or more, that it has done excellent service.

From this description it must be very evident that care in the selection of logs, and the manufacture and laying, are very essential to the durability and usefulness of this as any other kind of water pipe.

The saving effected by the adoption of this pipe over cast iron, at the lowest prices bid, was $24,330, which at compound interest at 8 per cent (the rate of interest of the Water Bonds) would in fifteen years amount to enough to relay the whole pipe system, if it should go entirely to pieces at the end of that time.

An incidental advantage arising from the use of this pipe has been the almost entire immunity from frost during the past severe winter, while many other cities which use cast iron exclusively have suffered severely. But a single instance has occurred of freezing, and that was in a private line laid too near the surface, and it has been thawed out without injury to the pipe.

Another reason which influenced the Board in selecting this pipe was the fact that the contractors guarantee their work for five years from the time of its completion, and give bonds to the city to keep it in repair during that time, while no bidder for cast iron pipe offered to guarantee for more than one year.

HYDRANTS.

The hydrants set by Mr. Peterson and one of those set by Farrington & Branch are Two-Nozzle *post* hydrants, manufactured by the Ludlow Valve Co. of Troy, N. Y., and are supplied by six inch branches from the mains. They are of excellent workmanship and have given good satisfaction. Repairs have been required on two of them, occasioned by gross carelessness in handling.

If any more post hydrants should be used hereafter, it would be advisable to have them made with a separate foot valve, in the branch or hydrant, so that the hydrant can be taken up for repairs without shutting off the mains, and with a separate valve for each nozzle, so that a second hose can be attached without shutting off the first.

These improvements have been introduced in the Cregier Hydrant and probably in others also.

This style of Hydrant was adopted for the same reason that occasioned the use of cast iron pipe, because there was no time to investigate the merits of the different styles, but when the contract was let to Farrington & Branch, the Board, after thorough investigation, decided to adopt the Lowry Hydrant as better adapted to the wants of this city. This hydrant is set directly over the main, and under the surface of the street, the base forming the four way or three way branch where two mains intersect and the stem having a diameter (here) of six inches.

The hydrant is enclosed in a wooden box resting on a brick foundation, with a heavy cast iron cover, in which is a circular hole for access, provided with a separate cover with a ring for lifting it.

The following advantages are claimed for this hydrant:

1st. That by taking the water directly from the main, and avoiding the friction and bend of the branch pipe, a greater volume will be discharged with the same pressure than from a post hydrant of the same size.

2nd. That being underneath the street and surrounded by dead air, it is less liable to be frozen in winter.

3rd. That being under ground and out of sight, it is less liable to be injured by runaway teams, or tampered with by thoughtless or designing persons.

4th. That it is cheaper than the post hydrant if, in the cost of the latter is included the cost of two branches in the main and the branch to the hydrant.

5th. That when in use, the hose will not block up the entire roadway of the street, as is sometimes the case with the post hydrant.

6th. That the hose head having four openings, three for hose connections, and one for the suction pipe of the steamer, it is equivalent to a post hydrant with four nozzles.

The apparent disadvantages are:

1st. That the hydrant cannot be used without a separate hose head, weighing about thirty pounds, which must be carried on every hose-cart.

2nd. That under ordinary circumstances it requires a little longer time to attach the hose, which in the commencement of a fire is an important matter.

3rd. That the covers must be kept free from snow and mud in freezing weather, and this requires care and labor.

4th. That the iron covers being always exposed, sometimes injure carriages and especially sleighs moving rapidly.

So far as our short experience goes, the merits of this hydrant largely overbalance the disadvantages. The labor required for keeping the covers clean has not been much greater than for boxing the post hydrants; the firemen by practice have learned to attach the hose with but trifling loss of time; there has been no trouble from freezing except in a few instances were the hydrants leaked, and the hydrants have been always accessible throughout the winter without the trouble of removing and replacing a box. Some damage has been done to vehicles which might have been avoided by reasonable care on the part of the drivers.

The hydrants set here are defective in some respects, both as to plan of construction and workmanship. These defects the contractors propose to remedy.

STOP VALVES.

A larger number of Stop Valves has been inserted in our pipe system than is usual, as it was thought good policy to divide the city into small sections, so that in case of the necessity of shutting off any section for repairs or extensions, but comparatively few consumers would be deprived of the use of the water. The valves set by Mr. Peterson were of the Ludlow, those set by Farrington and Branch of the Lowry pattern's.

BLOW OFF AND SAFETY VALVES.

The main in Lyon street is extended to the river, and one is laid on Allen street from the Front street main to the tail race, to serve as blow-offs for emptying the mains when necessary for cleansing them of sediment or for repairs. On each of these pipes a safety valve was inserted, which was used to regulate the pressure, while direct pressure alone was employed, and may now be used if necessary to regulate the height of water in the reservoir. In extending the system it will be advisable to occasionally insert blow-offs connecting with the sewers.

Appended to this report will be found schedules showing the location, size and length of all water mains laid, the location and size of stop valves, and the location of all hydrants.

RESERVOIR.

The site for the Reservoir was selected by the Board on the 27th of September 1873, but owing to the want of funds, the difficulty of agreeing with owners of the property to be taken, and the imperfections of the law for condemning land for public uses, it was not until the following May that title was finally obtained through the intervention of arbitrators. The grounds purchased include five and one half acres lying at the intersection of Livingston and Mason streets, on E. K. Powers' Addition, and including portions of those streets which have since been vacated by the action of the Common Council. Of these grounds the reservoir and its embankment occupy two and eight-tenths acres. The cost of the site was $25,050.

Plans for the reservoir had in the mean time been prepared by Mr. Hogan, who had been employed by the Board to superintend the construction of the Water Works, and on the 6th of June proposals were received for its construction.

Owing to the fact that some changes in the plans had been decided upon by the Board, and to the difficulty of making a precise estimate of quantities before the completion of the work, they were obliged to depart from the usual practice in this city and receive bids by items instead of a round sum.

Only two proposals were received of which the following is a copy:

PROPOSALS FOR RESERVOIR.

	Brooks & Sekell.	Carter Brothers.
Grubbing and Clearing	$62 00	$50 00
Excavation per Cubic Yard	00	25
Embankment " " "	39	75
Puddle " " "	1 09	1 50
Gravel Lining " " "	75	1 00
Brick Masonry " " "	10 50	$17.00 per sample $13.35 brick at $10
Concrete " " "	8 50	$5 00
Cobble Stone Paving, per Cubic yard, in mortar,	7 50	9 00
Cobble Stone Paving, per square yard, in sand	1 50	$7 per cubic yard
Brick Paving, per thousand brick	17 50	----------------
" " " square yard,	-----	$1.50 per sample $1.15 brick at $10
Timber & Plank, p. square ft., B. M.	25 00	$20 00
Gate House Complete	-----	$500 00

Taking Mr. Hogan's estimate of quantities as correct and adding $500 to Brooks & Sekell's bid for the Gate House, the comparative estimate of cost at these bids was:

Brooks & Sekell	$39,565 64
Carter Brothers	56,007 75

The actual cost of the reservoir as shown by the final settlement just made, is as follows:

34854 Cubic Yards Embankment	@$ 0.89	$13,593.06
8572 " " Puddle	@ 1.09	9,343.48
1178 4-10 Cubic Yards Concrete on Slopes	@ 8.50	10,016.40
722⅓ " " " " Bottom	@ 7.50	5,417.50
45 7-10 " " Stone Masonry	@ 7.50	342.75
14 " " Brick "	@ 10.50	147.00
55 " " Puddle worked over	@ 0.40	22.00
1902½ " " Cobble in Cement	@ 7.50	14,268.75
567⅔ Square " " " Sand	@ 1.50	851.50
Cut Stone for Carriage Truck		156.00
Water Table for Gate House		8.62
Roof and Door for Gate House		80.10
Wire, Carriage and Chain for Screen		59.72
Clearing and Grubbing		62.00
Labor making road around Reservoir		40.00
Total		$54,408.88

The actual cost is $14,847.24 in excess of the estimate made at the time of the letting.

This circumstance together with the fact that Mr. Hogan in his report had estimated the cost at $23,249.80 has led to so much criticism that an explanation will not be out of place.

In the first place Mr. Hogan's estimate of quantities was necessarily made on the assumption that the site would be level, while on the site finally selected there were three ravines, which largely increased the amount of embankment. In the second place the Board decided to make material changes in the plans, such as constructing stop walls along the pipes, substituting cobble stone paving for brick, and concrete lining on the bottom for gravel, and increasing the thickness of the concrete lining on the slopes. These changes with some variations in the actual measurement from the estimated quantities, made the following changes in the cost:

8918 Cubic yards additional embankment in ravines	@ $0.39	$3,478.02
163 4-10 Cubic yards additional Concrete on Slopes	@ 8.50	1,388.90
799 Cubic yards additional Puddle over estimate	@ 1.09	870.91
Increased cost of Concrete Lining over Gravel		5,002.75
" " " Cobble Paving over Brick,		3,750.47
Stone Masonry in Stop Walls, &c.,		342.75
Screen, Track and Road (not included in estimate)		255.72
Puddle worked over		22.00
		$15,111.28
Deduct cost of Gate House less than bid		264.28
Balance increased cost		$14,847.24

These same changes, together with the fact that the Board, in order to get more head to the water, decided, previous to the lettings, but subsequent to Mr. Hogan's estimate of cost, to raise the reservoir five feet higher than he had planned, will largely diminish the discrepancy between that estimate and the actual cost. This discrepancy was originally $31,159.08. By making the estimate conform to the changes made, and taking Mr. Hogan's prices as far as practicable, the discrepancy will be reduced as follows:

Original estimate		$23,249.80
Deduct Valves (not included in Brooks & Sekell's contract)	$ 375.00	
Deduct Sodding (not included in Brooks & Sekell's contract)	800.00	
Deduct Fencing (not included in Brooks & Sekell's contract)	475.00	
Deduct Gate House (original plan abandoned)	2,000.00	
" 4492 Cubic yards excavation saved by raising reservoir, @ 20c	898.40	4,548.40
Leaves		$18,701.40

Add 9317 Cubic yards embankment added by raising Reservoir, @ 30c	$2,795.10	
Add 8918 Cubic yards embankment added by Ravines, @ 30c	2,675.40	
Add 1317 Cubic yards Puddle added by raising Reservoir	658.50	
Add Change Concrete Lining for Gravel	5,002.57	
Add " Cobble Paving for Brick	3,750,47	
Add Additional Concrete on Slopes	1,388.90	
Gate House, Stop Valves, Screen and Road	834.19	17,105.31
Making the estimate now stand		$35,806.71
And reducing the discrepency to	$18,602.17	

Probably if Mr. Hogan had made his estimate after the Board decided to raise the Reservoir he would have made some changes in his prices.

The contract was awarded on the 12th of June to Thaddeus C. Brooks and Alfred C. Sekell, who immediately commenced work. It was not expected nor required that they should do more during the season, than would permit ten feet of water to be maintained during the winter, but unusually favorable weather, and the energy of the contractors enabled them to substantially complete the work before the setting in of frosts sufficiently severe to injure the masonry. Since the opening of Spring they have trimmed up the banks, and repaired the slight damage done to the paving by ice, and the work is now completed with the exception of sodding, which was not included in their contract. The work was done under the supervision of William Thornton, C. E., who was appointed by the Board as Inspector, and to his constant and intelligent attention, to the disposition manifested by the contractors to do good and honest work, and to the wisdom of the Board in making necessary changes in the plans, the City of Grand Rapids is indebted for what is probably one of the best reservoirs in the Western States.

The reservoir is in plan a circle 196 feet in diameter at the bottom and 271 feet at the top, and 25 feet in depth, of which on an average 4½ feet is in excavation and 20½ feet in embankment. The water line is intended to be kept at a height of 20 feet above the bottom, and when full to this height, the reservoir will contain six million gallons, and the water line will be 177 feet above low water in Grand River at the foot of Fulton street, or 154½ feet above the intersection of Monroe, Canal and Pearl streets.

The embankment is twelve feet wide on the top, and has an inner slope of 1½ feet horizontal to 1 foot vertical, and an outer slope of 2 to 1. It is formed mostly of sand, the only material that could be obtained, of which part was obtained from the excavation, and the remainder borrowed from Livingston street and adjoining lots. All roots, stumps and sod were first removed from the base of the embankment, and the embankment was then made in layers of about eight inches in thickness, and kept well wet down, and compacted as much as possible by rolling and the travel of the teams. The surface soil was reserved and used for making the outside of the embankment.

A vertical wall of puddle, eight feet in width at the bottom and five feet at the top, and of an average height of 21½ feet, is carried up through the center of the embankment, from the natural surface to within three feet of the top. A layer of puddle extends from the foot of the vertical wall nearly horizontally along the natural surface to the paving of the inner slope, having a thickness of 3 feet at its junction with the vertical wall and 2 feet at the inner slope. This layer is carried down under the paving of the slope and under the bottom of the reservoir, with a thickness of one foot, except under the toe of the slope paving, where its thickness is 1.6 feet. This puddle is formed of clay and sand mixed in suitable proportions, depending on the quality of the material, kept constantly wet and thoroughly worked up with spades in layers about six inches in thickness, until it is perfectly water-tight.

The inner slopes of the reservoir, to within two feet vertically of the top of the bank, are paved with cobble stones set at right angles to the face of the slope, with all interstices filled with cement mortar. The thickness of this paving is one foot, no stones of less depth being admitted. It rests on a bed of concrete one foot in thickness, formed of 1 part hydraulic cement, 2 of sand, 2 of screened gravel and 3 of broken stone. The upper two feet vertical of the slopes is paved with cobble stones six inches in depth set in sand, and this paving is carried back on the top of the bank to a distance of 2½ feet from the inner edge. The bottom of the reservoir is paved in the same manner as the slopes, except that the concrete and stone paving are each eight inches in thickness, and the concrete is made with gravel instead of broken stone. The original plan provided for a paving on the bottom six inches in thickness, resting on a lining of gravel of the same thickness, but the Board decided to adopt the greater thickness, and the use of concrete instead of gravel, for greater safety, on account of the extremely pervious nature of the soil, and the disastrous consequences which, from the location of the reservoir, would be likely to result from leakage. The plan also provided for a paving of brick, but on account of the difficulty of obtaining brick which would resist frost without injury, it became necessary to substitute cobble stone paving. Both these changes somewhat increased the cost of the reservoir, but added greatly to its safety and efficiency.

The force main 16 inches in diameter coming up Mason street from the west, and the outlet pipe 20 inches in diameter, passing out to the south in Livingston street, are of cast iron, and are carried under the embankment in trenches cut in the natural surface. At each joint a stop wall of masonry is built to prevent settlement of the pipe and to prevent water from following it. These walls on the force main are 2.5x3.4 ft.x4 ft. and those on the outlet pipe 3.2 ft.x3.8 ft.x4 ft. The inner end of the force main is enclosed in a solid mass of masonry of the form shown in the accompanying cross section. The end of the pipe is turned up, but a horizontal branch now closed with a plug, affords means for emptying the reservoir when necessary.

The gate house on the outlet pipe is a plain brick structure, eight feet square and ten feet high with flat roof, and is located at the outer toe of the embankment.

The inner end of the outlet pipe is connected with a chamber of brick masonry three feet square, open at the top, the opening being covered with a screen of no. 13 copper wire with ⅛ inch meshes. The screen is attached to a carriage, which, when necessary for cleaning or repairs, can be drawn up a grooved track of Joliet flagging, by means of a chain passing over a windlass at the top of the bank. The windlass is yet to be provided.

In order to protect the outer slope of the embankment from wash, it will be necessary to sod it, or sow it down with grass seed during the coming season.

In order to provide for emptying the reservoir in case of necessity, a waste pipe twelve inches in diameter has been laid down Mason street, from a branch in the force main near Ionia street to the River. This pipe would empty the entire reservoir in about nineteen hours.

A rough tight board fence eight feet in height has been built around the toe of the embankment to keep out persons who have caused annoyance by throwing stones and sticks into the reservoir.

ENGINE HOUSE.

The site for the Engine House was purchased in January 1874, for $5000, and includes five lots on the northwest corner of Canal and Coldbrook streets, 250 feet on Canal street and 186 on Coldbrook, having Grand River on the west, and including the mouth of Coldbrook Creek.

A site on higher ground was at first contemplated, but difficulties in procuring water rights on streams from which it was expected to obtain the supply of water, made it advisable to locate the works near the river, so that if necessary the water of these streams could be taken near their mouths, and the water from the river could be used as a temporary supply.

The plans and specifications were prepared by Mr. Hogan, the details by Mr. D. S. Hopkins, Architect, and the contract let August 1st. Owing to uncertainty as to the depth of the bed rock, and the probability of changes in the plans for the Engine beds, the foundations and excavation were bid for by the cubic yard. Filling was also bid for in the same way, as the Board did not desire to do any more at present than was absolutely necessary.

Six bids were received of which the following is a schedule:

	BUILDING.	FOUNDATIONS.	EXCAVATION.	FILLING.
Robert Hilton & Son.	$12.100	$4.25 per cb. yd.	40c. per cb. yd.	25c. per cb. yd.
John S. Farr & Co....	13.016	4.90 " " "	30c. " " "	30c. " " "
J. H. Courtney.........	18.800			
Harvey Varcent........	13.000	3.50 per perch.	$1.00 " " "	50c. " " "
Walter L. Culver & James Curtis..........	16.525 incl. 9 ft. of foundation.	3.00 " "	25c. " " "	25c. " " "
William Maunder & Joel Collins...........	12.043	2.40 per perch.	50c. " " "	30c. " " "

The contract was awarded to Robert Hilton & Son, with whom Robert Davidson was associated, and the work has just been completed, but not yet accepted. The following is the final account of work done under the contract:

Carpenter Work on Building, as per contract...	$5,100.00	
Mason " " " " " " ...	7,000.00	
906 Cubic Yards Excavation, @ 40 cents......	362.00	
1337 Cubic Yards Filling, @ 25 cents..........	334.25	
1569 67-100 Cubic Yards Stone Masonry, @ $4.25	6,671.10	
Extra Carpenter Work, not in specifications....	613.62	$20,390.20
Deduct 23½ squares Brick flooring, @ $5.70.....		133.95
Total..		$20,256.25

The above work includes settling well, culvert and valve chambers outside the building, and retaining walls 106 feet long and 6 feet 4 inches high on both sides of the creek from the culvert under Canal street to the river.

Other parties have furnished materials and labor to the amount of $962.21, making the total cost to date $21,018.46.

There is still to be done to complete the work the gas fitting, plumbing and painting of the building, the laying of floors in the Engine and Boiler rooms, some additional filling on the grounds and a fence around them, an arch over the creek, and a shed for storing fuel.

The foundations of the building and of the Engine and Boiler beds rest on the solid limestone rock, which here forms the bed of the river, and was found at an average depth of 13 feet 10½ inches below the top of the water table. The foundations of the building, to within two feet of the water table are of rubble masonry, with an average thickness of 3 feet 10 inches on the bottom and 2 feet 3 inches on the top. The upper two feet is of coursed masonry eighteen inches thick. The water table, window sills and coping of the engine beds, are of Joliet limestone; all the rest of the stone was taken from the bed of the river, except a few boulders.

The water table is 2 feet above the adopted grade of Canal street, and 6 feet 9 inches above high water mark.

The outside dimensions of the building are: Tower 16'x11', Engine Room 74'8"x44', Boiler Room 40'8"x42'. The walls are of hard burnt brick sixteen inches thick.

The building is covered with a Mansard roof, with dormer windows, which, over the tower and engine room forms a second story. The deck of the roof is covered with tin and the sides with slates.

The engine and boiler foundations are constructed for two sets of machinery, but only one will be used at present. The former, as well as the settling well and connections, were built under the supervision of Mr. Charles W. Knight, who showed himself entirely competent for the position. The boiler foundations are of solid masonry, each 12'x25' and

14½ feet high. Some expense might have been saved by making them hollow, and filling them with sand, but this was not in the plans, and was not thought of in time.

The foundation of the chimney is of solid masonry, 15 feet 2 inches in height, hexagonal, 6½ feet on a side, 2 feet below the water table and 8½ feet at the bottom, the upper 2 feet being vertical and 5½ feet on a side. The shaft is 101 feet in height above the water table, and is built of brick and surmounted by a cast iron cap. The hot air flue is 4 feet in diameter and is lined with fire-brick for 3 feet below and 10 feet above the smoke flue entrance.

The settling well is ten feet in inside diameter and 13½ feet deep. The walls are of brick, 12 inches in thickness for the first 4 feet 9 inches and 8 inches thick for 8 feet 9 inches. It is connected by a brick conduit 37½ feet long, and 2 feet in diameter with 8 inch walls, with Coldbrook Creek, from which the supply of water will be taken for the present. A 20 inch cast iron supply pipe, connecting with the pump well is laid in such a manner that the future supply can be brought in either from the north or east. For the present it is connected with the setting well by a branch which can be shut off by a valve, when any other source of supply than Coldbrook is to be used.

PUMPING MACHINERY.

Proposals for constructing and setting up Pumping Machinery, including Engines, Boilers and Pumps, were received on the 31st day of March, 1874. Each bidder was permitted to propose machinery of such design as he saw fit, but with the restriction that it must be capable of raising 1,250,000 gallons of water 160 feet high in 12 hours. The following bids were received:

HENRY C. HASKELL, ALBANY, N. Y.

Low Pressure Beane Engine 26" bore, 42" stroke	$13,000	
Two Tubular Boilers 4'9" shell, 15' long, with 100-3" tubes	4,000	$17,000

WEIMER & BIRKINBINE, PHILADELPHIA, PENN.

Condensing Engine 40" Steam Cylinder, 16" Water Cylinder, 4' stroke	$14,800
Boilers	3,700
	$18,500

E. P. ALLIS & CO., MILWAUKEE, WIS.

Horizontal Condensing Engine 24" Steam Cylinder, 16" Water Cylinder, 3' stroke.—Two Tubular Boilers 54" diameter, 16' long	$20,000

HENRY R. WORTHINGTON, NEW YORK.

Duplex Condensing Engine and Boilers, including foundations six feet high, Steam Cylinders 48"x36" and 24"x36", Water Cylinder 17½"x36"	$21,500
Duplex Non-Condensing Engine & Boilers	17,000

HOLLY MANUFACTURING CO., LOCKPORT, N. Y.

Engine, Pumps and Boilers complete, 4 Steam Cylinders 18" diameter 27" stroke, Water Cylinders 10¼" diameter, 3 Tubular Boilers 5' diameter 16' long, with 52 3¾" tubes	$40,000

VERGENNES MACHINE CO, VERGENNES, VT.

One set J. P. Flanders' Double Acting Plunger Pumps, with 2 Cylinders 14"x20", One Corliss Engine 150 Horse Power, Two Tubular Boilers 100 Horse Power, each	$29,600
Two Flanders' Pumps with two Cylinders each, and above steam power	29,600
One Pump as above without steam power	13,600
Two Pumps as " " " "	13,600

Each set to have the same capacity.

COPE & MAXWELL, CINCINNATI, O.

Compound Duplex Engine, Steam Cylinders 24"x48" and 14"x48", Water Cylinder 12"x48" with boilers	$20,360
Compound Condensing Engine, Steam Cylinders 34"x48" and 20"x48", Water Cylinder 17"x48" with boilers	17,360
Duplex Non-Condensing Engine, Steam Cylinders 20"x48", Water Cylinders 12"x48"	13,360
Direct Acting High Pressure Engine, Steam Cylinders 30"x48", Water Cylinders 17"x48"	12,360

CHARLES B. HARDICK, BROOKLYN, N. Y.

Two Niagara Direct Double Acting Piston Pumps, Steam Cylinders 32"x48", Water Cylinders 16"x48", without boilers	$12,000

WATERTOWN STEAM ENGINE CO., WATERTOWN, N. Y.

Two Double Acting Piston Pumps, Cylinders 16"x42"	$8,200
Two Condensing Engines, Cylinders 15"x24" and two return tubular boilers 60" diameter 12' long, each having 75 3" tubes	8,680
	$16,880

BUTTERWORTH & LOWE, GRAND RAPIDS, MICH.

Double Acting Condensing Engine, Steam Cylinder 33" diameter, Water Cylinder 16" diameter, 6 feet stroke and Tubular Boiler 6½ feet diameter, 16 feet long with 90 4 inch tubes	$16,500

Before making their award a committee of the Board visited South Bend, Toledo and Detroit, and examined the pumping engines in these places, and after their return the contract was awarded on the 18th of April to Butterworth & Lowe.

The contract with these gentlemen provided that the machinery should be completed and set up by the 1st day of November 1874, but various causes have delayed the completion of the contract, and the machinery is not yet ready for use. It is hoped that it will be in operation some time during the present month.

The machinery was designed by Mr. Demetrius Turner, Mechanical Engineer of this city, and has been constructed under his supervision as Inspector on behalf of the Board. Some additions have been made to the original design, such as a water-leg on the boiler, which will somewhat increase the cost.

It is expected that this machinery will, for a number of years, be able, by pumping from six to twelve hours a day, to supply all the water that will ordinarily be consumed, and that it will be a long time before it will be necessary to duplicate it.

The Force Main 16 inches in diameter passes from the engine house in a curve across Canal and Coldbrook streets to the head of Ottawa street, thence south in Ottawa street to Mason street, and east in Mason street to the reservoir. The large mains now laid in Ottawa, Mason and Canal streets, connect directly with the Force Main, and through these all other mains are so connected. This method of piping makes our system of Water Works a combination of the Direct Pressure and the Reservoir Systems, the pressure upon the pumps being regulated by the head of the reservoir instead of any special machinery. Ordinarily, while the pumps are running, the supply will be by the direct pressure, the surplus only going into the reservoir, to be drawn on when the pumps are shut down. In case however of a great conflagration, if another should ever occur, the reservoir may be shut off, and the pressure in the pipes raised as high as the capacity of the pumps will permit. In this way the main advantage of direct pressure will be attained, while the heavy expense attendant upon constant pumping for ordinary service will be avoided, and we shall have the additional safety of a reserve constantly stored in the reservoir to meet any temporary failure of the pumps, which is out of the question in every system where direct pressure alone is used.

TEMPORARY PUMPING MACHINERY.

When the pipe was laid in the Fall of 1873, the City having no pumping machinery of its own, connections were made with the pumps of Messrs. Nelson, Matter & Co., Butterworth & Lowe, A. Leitelt Bros. & Co., and C. C. Comstock and the small private reservoir of Mr. Comstock, for the purpose of temporary fire protection and supply of consumers.

Before the pipe was laid over Pearl Street Bridge, connections were made with the pumps at the Brush Factory, Star Mills and Powers' Mill for similar use on the west side. Several of these pumps being rotary, soon got out of order, and were unable to furnish the necessary supply, especially during the construction of the reservoir, which required large quantities of water. The Board was therefore compelled to purchase in August, 1874, a Worthington Duplex high pressure pumping engine, with Steam Cylinders 18½ inches and Water Cylinders 14 inches in diameter and 10 inches stroke.

This engine was set up on a timber foundation on the east bank of the river, at the foot of Mason street, and connected with the 12 inch main on that street. A boiler was hired of A. Leitelt Bros. & Co., but proving of insufficient capacity during the extreme cold weather, a second one was hired of the same parties. The cost of this engine, including freight, foundations and setting up, was $2,331.75. Up to the present time it has furnished all the water necessary for ordinary consumption and fire purposes, and when the new engine is completed, this one can be sold, or set up in the new engine house, to be used as a reserve in case of necessity.

A rough frame building has been built over the engine at an expense of $250.39, which by the terms of the lease of the site, is to belong to the owner of the ground, when no longer needed by the city.

PIPE ACROSS GRAND RIVER.

The original plan of the Board for supplying that part of the city lying west of Grand River, was by a cast iron pipe, with J. F. Ward's or some other flexible joint, laid in a trench excavated in the rock bed of the river.

The bids received for this work were so high, that this plan was for a time, abandoned, and the Board concluded to try a wooden pipe suspended by cables from the piers of one of the bridges, and protected from frost by a covering of felt. Further reflection lead to the abandonment of this project, the principal inducements being the frail character of the old piers, and the danger of injury to the pipe in case the bridge should take fire.

The Board then returned to their original plan of laying the pipe in the bed of the river, but determined to use a pipe made of boiler iron.

The contract for the pipe was awarded to Carter & Sullivan, at 7½ cents per pound, on the 9th of September, and on the 31st of October was completed at a cost of $1,592.33. The pipe is made of the best No. 1 charcoal iron, No. 8 wire guage in thickness and 12 inches in diameter. It is made in lengths of about 42 feet, with wrought iron spring flanges 5-sixteenths of an inch thick and 2½ inches wide. There are seventeen lengths which will lay about seven hundred feet. The pipe has been painted to protect it temporarily from the weather, but before being laid it is to be coated inside and out while hot, with a preparation of asphaltum and coal tar.

Proposals were received for excavating the trench, but being thought too high, the Board commenced the work by day labor, using a coffer dam made of bags filled with sand, and carried it on successfully about one hundred feet from the east bank, but a rise of the water caused by shutting off one of the canals, compelled a suspension of the work, and before it could be resumed, the water became so cold that it had to be postponed for the season. The excavation of the trench and the laying of the pipe will be completed as soon as the height and temperature of the water will permit.

In order to provide a temporary supply for the West Side, a six inch Wyckoff pipe was laid on the floor of the Pearl Street Bridge. It is enclosed in a pine box 22x24 inches on the inside and made of two courses of inch lumber breaking joints. The box was filled with saw-dust bedding from a livery stable. The pipe has given no trouble during the late severe winter.

OPERATION OF THE WORKS.

The operation of the Water Works not being in the charge of your Engineer, it will be sufficient for him to state that up to May 1st the entire cost of operation has been $6,666.09. Two hundred and thirteen permits for tapping have been granted, for which the city has collected five dollars each. Out of this the city pays for the tapping and the stop-cock at the main.

Licenses for tapping and general plumbing have been granted to Thomas Smith & Co., and Schriver, Weatherly & Co., and for plumbing alone to Williams, Smith & Watkins, Horan & McDermott, William A. Brown, and William S. Gunn & Co.

The disposition to waste the water, which is so general a subject of complaint in other cities, has manifested itself here in an aggravated form, and the Board has been compelled to commence the introduction of Water Meters. Five meters have been purchased of the Union Water Meter Company of Worcester, Mass., and are to be put in at the principal hotels and livery stables. The use of meters will no doubt have to be resorted to largely, notwithstanding their expense, and the sanitary objections to their general use.

The expenses of operation have been large, especially for pumping, owing to the desire of the Board to furnish fire protection, and comply with the demands of consumers, previous to the completion of the works, but it is expected that there will be considerable proportionate decrease in this expense after the new engine is in operation.

SUPPLY OF WATER.

For the present the supply of water is being taken from Grand River, and during the past winter there has been no complaint as to its quality. The new engine will take water from Coldbrook Creek, and measures are being taken to have the Creek cleared out, and everything removed from its banks which would be likely to injuriously affect the water. The want of funds has prevented any definite steps being taken towards securing any other source of supply as was contemplated in the original plan for the works, but the recent action of the Legislature in authorizing the raising of additional funds, will enable the Board during the present season to bring in a supply of whose quality there can be no question.

Measurements have been made by means of Weirs of the flow of Carrier, Coldbrook and Lamberton Creeks, and the results, calculated by J. B. Francis Formula, are as follows:

Carrier Creek	818,440	gallons per day.
Coldbrook Creek	999,926	" " "
Lamberton "	3.500.000	" " "

The last measurement was made in winter under unfavorable circumstances.

Annexed to this report will be found copies of the reports of R. C. Kedzie, of the Michigan State Agricultural College, on the analysis of water from the several sources of supply which have been proposed during the discussion which has been carried on upon this subject.

COST OF WATER WORKS.

The total cost of construction of the Water Works to date has been as follows:

Paid to date on Real Estate	$ 30,050.00
Pipe System	122,690.69
Pipe under River	2,004.75
Connections with Pumps	364.37
Reservoir	51,175.50
Fence around Reservoir	226.38
Permanent Engine House	21,018.06
Temporary " "	250.39
" Pumping Machinery	2,331.75
Permanent " "	14,181.81
Engineering and Superintendence	2,972.47
Printing and Advertising	152.50
Expenses of Loan	463.01
Hose Heads	600.00
Miscellaneous	290.79
Total Payments	$248,772.47

Due on Pipe System	$13,758.85	
Reservoir	3,233.38	
Engine House	1,810.40	
Pumping Machinery	4,351.00	
Engineering, &c.	2,597.00	25,750.63
Total Cost		$274,523.10

Respectfully Submitted.

EMORY W. MUENSCHER,
City Engineer.

PROF. KEDZIE'S REPORT ON ANALYSIS OF WATER.

Lansing, August 12, 1872.

HON. J. HOUSEMAN, Mayor of Grand Rapids.

Dear Sir:—I have analysed the two specimens of water sent me from Grand Rapids, marked No. 1, No. 2. The water marked No. 1 contains 9 grains of mineral matter in the gallon, and No. 2 12.49 grains. The water sent by Mr. Coats from the Hydraulic Co.'s well contained 9.02 grains. It will be seen thus that the amount of mineral matter does not vary greatly. The result of these three analysis are contained in the following table:

	No. 1.	No. 2.	Hydraulic.
Total mineral matter in grain, gallons	9.00	12.49	9.02
Consisting of			
Silica	.75	1.37	.65
Oxide of Iron	.85	.72	.25
Carbonate of Lime	4.65	7.18	6.23
Carbonate of Magnesia	1.13	1.84	.90
Phosphate of Lime	trace.	trace.	trace.
Chloride of Potassium and Sodium	1.62	1.38	.99

It is a little remarkable that these waters contain no sensible quantity of Sulphate of Lime, notwithstanding their being in the vicinity of the plaster beds.

I estimated the value of these waters for laundry purposes by means of Clark's Soap Test, and found the hardness of the water was: Hydraulic Well 12.2, No. 1 9.12, and and No. 2 13.4. These figures express the relative amount of loss in the use of soap, arising from the hardness of the water. In washing No. 1 is the best, the Well water next, and No. 2 poorest.

For domestic purposes the value of these waters is poorly expressed by the table of analysis given above. No. 1 and No. 2 are entirely unfit for domestic use on account of the large amount of organic matter which they contain. The difference in this respect in these three specimens of water is very remarkable. The water from the well has only a slight trace of organic matter—so little as to only slightly decolorize a delicate solution of permanganate of potash in twenty-four hours.

No. 2 contains much more and No. 1 a large amount. If we represent the amount of organic matter in the Hydraulic Well as 1, that in No. 2 will be 8⅔ and in No. 1 will be 18⅔.

On examination of No. 1 by microscope it was found to abound in large numbers of animalculae, of which four or five species were recognized. Some of these animalculae are visible to the naked eye; but the largest number are microscopic. If the water is placed in a tall glass vessel, and suffered to become tranquil, and is then viewed by transmitted light, some of the insects are visible to the naked eye—often in rapid motion. These animalculae are such as are often found in stagnant ponds, and shallow lakes, abounding in water lilies and sedges.

No. 2 also contains a considerable number of animalculae, but they are all invisible to the unassisted eye. They are readily visible in the field of a compound microscope of low power.

The animalculae differ from those in No. 1, and are found most abundantly in the sediment which subsides when the water remains undisturbed for a short time.

The insects in both these specimens of water can only live in water which contains putrescent organic matter, and such water is entirely unfit for domestic uses.

The water from the hydraulic well contains none of these insects—contains only a trace of organic matter, and is very much superior to either of the other specimens sent for examination.

The well water is good not only in comparison with No. 1 and No. 2, but it is an excellent water judged by itself.

I would recommend this water in preference to either of the other specimens sent, to supply your city for domestic use.

Very respectfully,
R. C. KEDZIE,
Prof. Chemistry Agric. College.

Lansing, June 3d, 1873.

HON. THOS. D. GILBERT.

Dear Sir:—I send you the results of chemical examination of Water No.'s 1, 2 and 3, sent me from Grand Rapids. I have directed my examination principally to those substances which might injuriously affect the water for domestic use. The total amount of solid matter varies in the different specimens, and there is a large difference in the amount of *organic matter in solution*: No. 2 containing much less than No. 1 and 3. All of these waters contain living organisms; the first specimens sent (i. e. the first set of jugs) contained a larger number of organisms of microscopic proportions than did the second set of specimens. No.'s 1 and 3 contain a large number of animalculae and the species in each kind are similar. In number 2, *the number is much smaller* than in the other specimens of water, and they are different in species.

Notwithstanding the comparatively large amount of solid matter in No. 2 as compared with No.'s 1 and 3, I pronounce it the best for domestic use, because it contains much less organic matter and is freer from low forms of animal life.

Very respectfully,
R. C. KEDZIE,
Prof. Chem., &c.

NOTE.—Water from Reed's Lake is designated No. 1 in this analysis, and that from Grand River No. 2.

RESULTS OF ANALYSIS OF WATER FROM GRAND RAPIDS.

Solid matter (in grains) in Imperial gallon of ten pounds.

	No. 1.	No. 2.	No. 3.
Sulphate of Lime	3.17	2.45	1.47
Carbonate of Lime	9.03	9.20	1.08
Carbonate of Magnesia	1.55	6.35	1.53
Soluble Silica	1.75	2.03	1.40
Chlorides of Sodium and Potassium	2.38	1.96	2.10
Organic Matter in Solution	1.92	.98	2.71
Total Grains of Solid Matter	19.80	22.97	10.29
Hardness by Soap Test	18°	16°	17°

NOTE. The water in Specimen No. 1 is from Lamberton Creek; No. 2 contains equal parts of water from Carrier and Coldbrook Creeks, taken at the points where it has been proposed to obtain a supply; and No. 3 equal parts from Carrier and Coldbrook Creeks and the outlet of Reed's Lake.

LIST OF WATER MAINS.—May 1st, 1875.

EAST SIDE.

STREET.	FROM.	TO.	LENGTH Ft. In.	SIZE IN.	REMARKS.
Barclay	Bridge	Bronson	500–9	14	Wood
Bridge	Canal	Ottawa	605–0	12	Iron
"	Ottawa	Coit	1530–3	12	Wood except 11 f. 2 in. iron
"	Coit	Barclay	184–5	14	Wood
Bronson	Barclay	Lafayette	500–11	14	"
Campau	Pearl	County Jail	443–2	4	"
Canal	Pearl	Bridge	1496–0	10	Iron
"	Engine House	Leonard	831–5	12	Wood
"	Leonard	Robinson & Solomon, Mill	2158–2	8	" except 8 feet iron
"	R. & S. Mill	North Limits	436–0	6	"
Cherry	Jefferson Ave.	Lafayette	657–8	8	"
Coit Ave.	Bridge	Hastings	603–7	14	"
Division	Bridge	Cherry	3962–2	12	"
Erie	Canal	Leitelt's Shop	181–0	4	Iron
Fulton	Division	Prospect	2074–2	10	Wood
Hastings	Coit	Livingston	405–2	14	"
Huron	Canal	Butterworth's Shop.	294–0	4	Iron
Ionia	Pearl	Oakes	2102–0	6	Wood except 6 f. 10 in. iron
Jefferson Ave.	Fulton	Wealthy	2635–3	6	Wood
Kent	Bridge	Trowbridge	1168–9	6	" except 4 feet iron
Lafayette	Bronson	Lyon	551–5	14	Wood
"	Lyon	Fulton	1574–6	8	"
"	Fulton	Cherry	1143–10	4	"
Ledyard Alley	Pearl	Rear of Block	172–2	6	"
Leonard	N. Canal	S. Canal	37–2	12	Wood
Livingston	Hastings	Newberry	1697–10	14	"
Livingston	Newberry	Reservoir	272–3	20	Iron
Louis	Waterloo	Campau	429–4	4	Wood
Lyon	Nel., Mat. & Co.	Canal	445–0	6	Iron
"	Canal	Ottawa	596–7	10	Wood except 9 f. 11 in. iron
"	Ottawa	Division	510–0	10	Iron
"	Division	Lafayette	1673–6	10	Wood
Mason	Reservoir	Ottawa	948–6	16	Wood except 48 ft. iron
"	Ottawa	Canal	611–5	12	Wood
Monroe	Pearl	Ottawa	692–0	10	Iron
"	Ottawa	Division	801–0	12	"
Ottawa	Monroe	Newberry	4255–6	12	"
"	Newberry	Mason	581–7	12	Wood except 10 f. 9 in. iron
"	Mason	Engine House	1612–8	16	Wood except 90 f. 6 in. iron
Pearl	Division	Valve at river	1566–5	6	Wood except 13 ft. 8 in. iron
Waterloo	Monroe	Fulton	1049–0	8	Wood except 3 f. 8 in. iron

LIST OF WATER MAINS.—May 1st, 1875.

WEST SIDE.

STREET.	FROM.	TO.	LENGTH Ft. In.	SIZE IN.	REMARKS.
Allen	Summer	Winter	294–5	8	Wood
Bridge	Front	Stocking	2029–3	12	“
Broadway	Bridge	Eighth	2866–11	12	“
Eighth	Broadway	Front	940–0	12	“
Fifth	Broadway	Seward	872–2	6	“
Front	Bridge	Shawmut	1670–1	6	“
Jefferson	Bridge	Sibley	1819–3	4	“
Scribner	Bridge	Eighth	2839–0	6	“
“	Eighth	Webster	4238–4	8	“
Summer	Bridge	Blossom	2159–6	4	“
Third	Broadway	Seward	823–8	4	“
Winter	Allen	Shawmut	474–5	4	“

NOT AVAILABLE FOR TAPPING.

Lyon	Safety Valve to River	24–0	6	Iron
“	Branch to Nelson & Matter's Pump	42–0	4	“
Erie	Branch to Leitelt's Pump	19–0	4	“
Huron	“ “ Butterworth's do.	30–6	4	“
Front	“ “ Brush Factory do.	45–6	6	Wood
“	“ “ Powers' Pump	45–3	4	“
“	“ “ Star Mills “	56–11	4	“
Allen	Blow off	62–3	8	“
Livingston	Inside of Reservoir to Valve	77–3	20	Iron
Mason	“ “ “ “ “	109–0	16	“
“	Canal to River	10–11	12	Wood
“	Waste, Ionia to River	1042–5	12	“
Pearl St. Br'ge		875–0	6	“
At Engine House.	Supply Pipes	114–11	20	Iron
	Branches to Hydrants	294–6	6	Iron

TOTAL PIPE LAID.

	20''	16''	14''	12''	10''	8''	6''	4''	TOTAL.
Iron	464–5	247–6	....	5683–5	2707–11	11–8	788–0	566–6	10469–5
Wood	....	2424–8	4444–1	14421–7	4334–4	10022–7	14357–10	6895–4	56900–5
Total	464–5	2672–2	4444–1	20105–0	7042–3	10034–3	15145–10	7461–10	67369–10

12 401-528 miles.

LIST OF STOP VALVES.

STREET.	LOCATION.	SIZE. inch.
Barclay	South Line Bridge St.	14
Bridge East	West " Coit Ave	12
" "	" " Division St.	12
Bridge West	East " Front St.	12
" "	" " Summer St.	12
" "	West " Broadway St.	12
" "	" " Stocking "	12
Broadway	North " Bridge "	12
"	South " Eighth "	12
Canal	" " Lyon "	10
"	" " Bridge "	10
"	At Engine House	12
"	North Line Leonard St.	8
"	North Limits of City	6
Cherry	West Line Lafayette St.	8
Coit Ave	North Line Bridge "	14
Division	South " " "	12
"	" " Lyon "	12
"	" " Fulton "	12
Eighth	West " Scribner "	12
"	East " Front "	12
Engine House	North end Supply Pipe	20
" "	South " " "	20
" "	At Well	20
Erie	On Branch to A. Leitelt Bros. & Co. Shop	4
Fifth	West Line Broadway St.	6
Front	South " Bridge "	6
"	On Branch to Brush Factory	6
"	" " " Powers' Mill	4
"	" " " Star Mills	4
Fulton	East Line Division St.	10
"	West " Lafayette "	10
Ionia	East " Monroe "	6
"	West " " "	6
Jefferson Ave.	South " Fulton "	6
" "	North " Wealthy Ave.	6
Jefferson St.	South " Bridge St.	4
Kent	North " " "	6

LIST OF STOP VALVES.

STREET.	LOCATION.	SIZE. inch.
Lafayette	North “ Fulton “	8
“	South “ Lyon “	8
Livingston	Foot of Reservoir Bank	20
Lyon	West Line Ottawa St.	10
“	“ “ Division “	10
“	East “ “ “	10
“	West “ Lafayette St.	10
Mason	Foot of Reservoir Bank	16
“	East Line Ionia St., on waste pipe	12
“	“ “ Ottawa St.	16
“	West “ “ “	12
“	“ “ Canal “	12
Monroe	“ “ Division “	12
“	“ “ Ottawa “	10
Ottawa	East “ Monroe “	12
“	South “ Bridge “	12
“	North “ “ “	12
“	South “ Newberry St.	12
“	North “ Mason “	16
“	South “ Coldbrook “	16
“	On Connection with Comstock's Reservoir	4
Pearl	West Line Division St.	6
“	“ “ Ottawa “	6
“	“ “ Canal “	6
“	East End Pearl Street Bridge	6
“	West “ “ “ “	6
Scribner	North Line Bridge St.	6
“	South “ Eighth “	6
“	North “ “ “	8
“	South “ Leonard St.	8
“	North “ “ “	8
Summer	South “ Bridge “	4
Third	West “ Broadway “	4
Waterloo	West “ Monroe “	8

20 inch	16 inch	14 inch	12 inch	10 inch	8 inch.	6 inch.	4 inch.	TOTAL.
4	4	2	22	9	8	16	7	72

SAFETY VALVES.

On Lyon Street, at River.
On Allen Street, at Tail Race.

LOCATION OF LUDLOW HYDRANTS.

South West Corner Bridge and Kent.
“ “ “ “ “ Canal.
North “ “ Canal “ Erie.
“ “ “ “ “ Huron.
“ “ “ “ “ Lyon.
“ “ “ “ “ Pearl.
“ “ “ Lyon “ Ionia.
“ “ “ “ “ Division.
South East “ Monroe and Waterloo.
“ “ “ “ “ Ottawa.
“ “ “ “ “ Ionia.
“ “ “ “ “ Spring.
North East “ Ottawa “ Fountain.
“ West “ “ “ Pearl.
“ “ “ “ “ Lyon.
“ “ “ “ “ Bronson.
“ “ “ “ “ Bridge.
“ “ “ “ “ Hastings.
“ “ “ “ “ Trowbridge.
“ “ “ “ “ Fairbanks.
South “ “ “ “ Newberry.

LOCATION OF LOWRY HYDRANTS.

Intersection of Bridge St. East, with Barclay, Coit and Livingston.
“ “ “ “ “ “ Clinton, Ionia and Division.
“ “ “ “ West, “ Front, Scribner and Turner.
“ “ “ “ “ “ Broadway, Seward & Jefferson.
“ “ Bronson St., with Barclay and Lafayette.
“ “ Broadway St., with First, Second, Third & Fourth.
“ “ “ “ “ Fifth, Sixth, Seventh & Eighth.
“ “ Canal “ “ Leonard and Quimby.
“ “ Two between Leonard and Quimby.
“ “ One North of Quimby.
“ “ Cherry “ with Luce and Lafayette.
“ “ Division St., with Bronson, Fountain, Park, Fulton.
“ “ “ “ “ Island, Oakes and Cherry.
“ “ Eighth “ “ Turner, Scribner and Front.

Intersection of Fifth St., with Seward—one between Seward and Broadway.
" " Front " " Bowery, Valley, Allen & Shawmut
" " Fulton " " Sheldon, Ransom and Barclay.
" " " " " Lafayette and Prospect.
" " Hastings " " Coit and Livingston.
" " Ionia " " Fountain, Louis and Fulton.
" " " " " Island and Oakes.
" " Jefferson Ave., with Island, Oakes and Cherry.
" " " " " Maple, Goodrich & Wealthy.
" " Jefferson St., " Bowery, Chatham, Jackson and Sibley.
" " Kent " " Hastings and Trowbridge.
" " Lafayette " " Washington, John and Fountain.
" " Livingston St., with Trowbridge, Fairbanks and Newberry.
" " Louis " " Campau.
" " Lyon " " Kent, Bostwick & Ransom.
" " " " " Barclay and Lafayette.
" " Mason " " Clinton, Ionia, Kent & Canal
" " Ottawa " " Mason, Walbridge and Coldbrook.
" " Pearl " " Campau, Arcade, Ionia and Division.
" " Scribner " " First, Second, Third, Fourth and Fifth.
" " " " " Sixth, Tenth, Eleventh and Twelveth.
" " " " " Leonard, Crosby, Myrtle and Webster.
" " Summer " " Bowery, Allen, Shawmut and Blossom.
" " Third " " Alabama and Seward.
" " Waterloo " " Louis, Ferry and Fulton.
" " Winter " " Allen and Shawmut.

One in center of Section 8, Campau Plat.

Total Ludlow Hydrants,	21
" Lowry "	117
Total,	138
Total on East Side of Grand River,	90
" " West " " " "	48

STATEMENT OF EXPENDITURES TO MAY 1, '75.

CONSTRUCTION OF WATER WORKS.

1. REAL ESTATE.

1874.			
Jan.		C. W. Taylor, Engine House Site	$ 5000 00
April 20.	Order No. 2427.	P. R. L. Pierce, Reservoir Site	18575 00
" "	" " 2428.	P. R. L. Pierce, " "	1200 00
May 19.	" " 48.	W. S. Gunn, " "	900 00
" 26.	" " 80.	J. Houseman, " "	800 00
June 17.	" " 210.	J. Houseman, " "	1850 00
" 23.	" " 224.	J. Houseman, " "	1725 00
			$30,050 00

2. PIPE SYSTEM.

1873.			
Nov. 3.	Order No. 1204.	Chas. Peterson,	$ 3561 60
" 17.	" " 1343.	" "	12028 69
Dec. 1.	" " 1469.	" "	9695 95
" 15.	" " 1557.	" "	1759 72
" 29.	" " 1627.	" "	1535 68
" 29.	" " 1628.	" " Bill of Specials	731 43
" 29.	" " 1629.	" " Check Valves	31 83
1874.			
Jan. 26.	" " 1852.	" " per J. Van Every	1 95
" 26.	" " 1853.	" " " P. Coad	4 75
" 26.	" "	" " " " "	3 75
Feb. 9.	" " 1968.	Butterworth & Lowe (Check Valve)	103 69
" 16.	" " 1992.	Chas. Peterson (per Foster, Stevens & Co.)	824 21
" 16.	" " 1993.	Chas. Peterson	1169 84
March 16.	" " 2147.	" "	400 00
April 27.	" " 2484.	" "	600 00
June 17.	" " 201.	Farrington & Branch	6627 85
July 7.	" " 396.	" "	8596 71
July 21.	" " 478.	" " (per P. Coad)	31 00
Aug. 4.	" " 565.	" "	19554 57
Aug. 18.	" " 696.	W. H. Powers (Boxes for protecting pipe through culverts)	29 50
Sept. 1.	" " 806.	T. Smith & Co., (moving gas pipes)	5 00
" 1.	" " 807.	Farrington & Branch (per P. Coad)	14 50
" 8.	" " 884.	" "	19223 62
" 29.	" " 1111.	" " (per G. R. Hyd. Co.	6 00

Oct. 6.	Order No.	1149(½.)	Farrington & Branch (per E. Smith, Inspector)	$44 56
“ 6.	“	“ 1154.	Farrington & Branch (per P. Coad)	1 36
“ 6.	“	“ 1155(Pt.)	A. Leitelt Bros. & Co. (Safety Valve)	200 00
“ 6.	“	“ 1156.	Farrington & Branch	15557 60
“ 13.	“	“ 1169.	“ “ (per M. DeLong)	8 75
“ 20.	“	“ 1407.	M. C. Railroad (Freight on Valves)	28 11
Nov. 10.	“	“ 1590.	Farrington & Branch	10000 00
“ 17.	“	“ 1664(½).	Farrington & Branch (per E. Smith, Inspector)	72 78
Dec. 8.	“	“ 1869.	W. H. Powers (Box for pipe over Pearl Street Bridge)	282 42
“ 8.	“	“ 1921.	Farrington & Branch (per damages)	60 00
“ 8.	“	“ 1922.	“ “ “ “	25 00
“ 8.	“	“ 1923.	“ “ “ “	31 00
“ 15.	“	“ 1980.	“ “	5000 00
1875.				
Jan. 5.	“	“ 2081.	J. M. Zindel, (manure for box over Pearl Street Bridge)	27 00
“ 19.	“	“ 2218.	P. Coad, (covering pipes)	25 50
“ 26.	“	“ 2248.	Geo. W. Eddy, Valves	858 00
Feb. 16.	“	“ 2426.	Farrington & Branch	4000 00
April 20.	“	“ 3078.	“ “ per P. Coad . .	2 00

Total, including $100 for Hose Head $122,790 69

3. PIPE UNDER GRAND RIVER.

1874.				
Sept. 15.	Order No.	965.	Voight, Herpolsheimer & Co., Grain Bags	$ 30 50
Sept. 22.	“	“ 999.	P. W. King, Labor on trench . . .	163 04
“ 22.	“	“ 1025.	Voight, Herpolsheimer & Co., Grain Bags	61 00
“ 29.	“	“ 1102.	Carter & Sullivan, Pipe	480 00
“ 29.	“	“ 1112.	P. W. King, Labor on Trench . . .	113 53
Oct. 6.	“	“ 1147.	“ “ “ “ “ . . .	7 86
“ 13.	“	“ 1267.	Voight, Herpolsheimer & Co., Grain Bags	30 50
“ 20.	“	“ 1332.	Carter & Sullivan, Pipe	163 62
“ 29.	“	“ 1408.	P. W. King, Labor on Trench . . .	6 00
Nov. 3.	“	“ 1492.	Carter & Sullivan, Pipe	948 70

$2,004 75

4. CONNECTIONS WITH PUMPS.

1873.			
Dec. 22.	Order No. 1600.	A. Leitelt Bros. & Co., 2 connections	$ 78 54
1874.			
Jan. 5.	Order No. 1688.	Butterworth & Lowe, 1 connection	69 56
March 2.	" " 2625.	G. R. Gas Light Co., Pipe	29 68
Aug. 4.	" " 566.	W. H. Powers, 1 connection	27 78
Oct. 6.	" " 1155(Pt.)	A. Leitelt Bros. & Co., 2 connections	155 71
Dec. 15.	" " 1972.	Mangold, Hibbard & Co., Repairing Wall	3 10
			$364 67

5. RESERVOIR.

1874.			
Aug. 18.	Order No. 697.	Brooks & Sekell	$ 7,726 95
Oct. 20.	" " 1333.	" "	28,448 55
Nov. 24.	" " 1723.	" "	10,000 00
1875.			
Jan. 12.	" " 2188.	" "	5,000 00
April 28.	" " 3195.	A. C. Sekell, Fence	226 38
			$51,401 88

6. PERMANENT ENGINE HOUSE.

1874.			
Aug. 26.	Order No. 752.	R. Hilton & Son	$1,138 50
Sept. 1.	" " 808.	" "	1,541 25
" 15.	" " 963.	" "	1,030 50
" 29.	" " 1104.	" "	2,017 35
Oct. 13.	" " 1270.	Chas. W. Knight, Labor on Engine Beds	20 22
" 29.	" " 1409.	Chas. W. Knight, Labor on Engine Beds	66 00
Nov. 3.	" " 1491.	R. Hilton & Son	7,716 60
" 17.	" " 1668.	L. M. Page, Priming	11 77
" 17.	" " 1671.	Chas. W. Knight, Labor on Engine Beds, &c.	119 64
Dec. 15.	" " 1770.	Chas. W Knight, Labor on Engine Beds, &c.	17 90
Dec. 22.	" " 2013.	R. Hilton & Son	3,025 80
1775.			
Jan. 26.	" " 2249.	H. Christianson, Labor	32 25

March 2.	Order No. 2639.	Schmidt & Hirth, Cut Stone	184 77
“ 16.	“ “ 2767.	A. Leitelt Bros. & Co., Supplies	12 60
“ 30.	“ “ 2865.	R. C. Luce, Sewer Pipe	98 11
“ 30.	“ “ 2866.	Schriver, Weatherly & Co., Gas Pipe	77 48
“ 30.	“ “ 2868.	Foster, Stevens & Co., Supplies	17 07
April 20.	“ “ 3077.	Patrick Gill, Filling Boiler Room	56 25
“ 20.	“ “ 3079.	G. R. Gas Light Co., Coke	1 50
“ 20.	“ “ 3080.	H. Christianson, Labor	22 50
“ 28.	“ “ 3196.	R. Hilton & Son	2,000 00
			$21,018 06

7. TEMPORARY ENGINE HOUSE.

1874,			
Sept. 8.	Order No. 886.	L. Riddle, Labor	$34 00
“ 15.	“ “ 966.	G. N. Bowen, Labor	3 75
“ 22.	“ “ 1026.	W. H. Powers, Lumber	14 06
“ 26.	“ “ 1027.	W. T. Powers & Son, Lumber	108 49
Oct. 6.	“ “ 1157.	Foster, Stevens & Co., Hardware	11 96
Nov. 10.	“ “ 1598.	W. T. Powers & Son, Lumber	28 13
			$250 39

8. TEMPORARY PUMPING MACHINERY.

1874.			
Sept. 15.	Order No. 968.	A. Leitelt Bros. & Co., Worthington Engine	$1,618 75
Oct. 6.	“ “ 1155(Pt.)	A. Leitelt Bros. & Co., Fitting up	641 25
Oct. 13.	“ “ 1366.	A. Leitelt Bros. & Co., Fitting up	13 96
Oct. 13.	“ “ 1277.	A. Leitelt Bros. & Co., Fitting up	19 30
Oct. 13.	“ “ 1278.	A. Leitelt Bros. & Co., Fitting up	38 49
			$2,331 75

9. PERMANENT PUMPING MACHINERY.

1874.			
June 10.	Order No. 166.	Butterworth & Lowe	$ 600 00
July 7.	“ “ 397.	Butterworth & Lowe	2,060 00
Aug. 11.	“ “ 652.	Butterworth & Lowe	2,339 00
Sept. 8.	“ “ 888.	Butterworth & Lowe	1,725 00
Oct. 6.	“ “ 1150.	Butterworth & Lowe	2,550 00
Nov. 3.	“ “ 1494.	Butterworth & Lowe	1,875 00
Dec. 1.	“ “ 1756.	Carter & Sullivan, Water Leg	532 81
1875.			
March 16.	“ “ 2766.	Butterworth & Lowe	2,500 00
			$14,181 81

10. ENGINEERING & SUPERINTENDENCE.

1874.					
June	17.	Order No.	209.	Peter Hogan, General Services . .	$1,000 00
Aug.	4.	“ “	650.	Wm. Thornton, Reservoir	92 30
Aug.	11.	“ “	651.	Foster, Stevens & Co., Tools . . .	10 28
Sept.	15.	“ “	970.	Wm. Thornton, Reservoir	96 15
Sept.	29.	“ “	1103.	D. S. Hopkins, Engine House . . .	75 00
Oct.	6.	“ “	1149(½.)	Elihu Smith, Pipe	44 56
Oct.	6.	“ “	1160.	Wm. Thornton, Reservoir	100 00
Nov.	3.	“ “	1499.	Demetrius Turner, Engines	781 41
Nov.	10.	“ “	1500.	Wm. Thornton, Reservoir	100 00
Nov.	17.	“ “	1536.	Peter Hogan, Preliminary Report . .	500 00
Nov.	17.	“ “	1663.	Elihu Smith, Pipe	72 77
Dec.	8.	“ “	1864.	Wm. Thornton, Reservoir	100 00
					$2,972 47

11. PRINTING AND ADVERTISING.

1873.					
Dec.	15.	Order No.	1552.	M. H. Clark & Co.	$ 8 00
1874.					
April	13.	Order No.	2350.	Sexton & Church	19 00
April	20.	“ “	2418.	M. H. Clark & Co.	56 75
May	1.	“ “	2625.	M. H. Clark & Co.	20 00
June	10.	“ “	177.	M. H. Clark & Co.	8 40
June	30.	“ “	312.	J. Van Der Sluis	2 80
July	7.	“ “	317.	M. H. Clark & Co.	5 60
July	7.	“ “	385.	Sexton & Church	2 80
Aug.	11.	“ “	636.	M. H. Clark & Co.	6 30
Sept.	8.	“ “	909.	Sexton & Church	3 85
Sept.	15.	“ “	974.	M. H. Clark & Co.	1 50
Sept.	22.	“ “	1058.	J. Van Der Sluis	5 60
Oct.	6.	“ “	1231.	A. B. Turner & Co.	2 80
Oct.	20.	“ “	1343.	M. H. Clark & Co.	2 10
Nov.	3.	“ “	1510.	M. H. Clark & Co.	2 80
Dec.	8.	“ “	1901.	Sexton & Tarbox	2 80
Dec.	15.	“ “	1977.	M. H. Clark & Co.	1 40
					$152 50

12. EXPENSES OF WATER LOAN.

1874.					
March	9.	Order No.	2107.	P. R. L. Pierce, Mayor, expenses . .	$ 68 70
April	30.	“ “	2411.	P. R. L. Pierce, Mayor, expenses . .	30 74
April	30.	“ “	2412.	J. F. Baars, Treasurer, expenses . . .	33 00
May	12.	“ “	5.	P. R. L. Pierce, Mayor, expenses . . .	13 49
May	26.	“ “	70.	J. Houseman, Mayor, expenses . . .	100 75

1875.					
March	2.	Order No.	2562.	J. F. Baars, Treasurer, expenses . . .	155 45
April	28.	" "	3175.	J. F. Baars, Treasurer, expenses . . .	8 80
April	28.	" "	3178.	J. Houseman, Mayor, expenses	52 08
					$463 01

HOSE HEADS.

1874.					
Oct.	13.	Order No.	1279.	A. Leitelt Bros. & Co.	$500 00

14. MISCELLANEOUS.

1873.					
Dec.	1.	Order No.	1468.	P. Coad, Repair of Streets	4 50
Dec.	15.	" "	1558.	P. Coad, Repair of Streets	5 25
Dec.	29.	" "	1630.	J. Collins, Repair of Streets	18 00
1874.					
Jan.	5.	Order No.	1689.	R. Hilton & Son, Boxes for Hydrants	4 00
June	10.	" "	174.	W. T. Powers, expenses	22 40
July	7.	" "	327.	P. Coad, Repair of Streets	4 13
Sept.	1.	" "	815.	Foster, Stevens & Co., Supplies . . .	2 03
Oct.	6.	" "	1155(Pt.)	A. Leitelt Bros. & Co., Repair of Hydrants	17 00
Oct.	6.	" "	1161.	Thos. Smith & Co., Connection for Fountain	24 13
Nov.	3.	" "	1497.	Joel Collins, Connection for Fountain .	14 05
Nov.	3.	" "	1500.	John L. Shaw, Repair of Pipe . . .	16 30
Nov.	30.	" "	1665.	E. A. Dapper, Legal	75 00
Dec.	8.	" "	1862.	John Jellen, Posts for Hydrants . . .	55 00
Dec.	8.	" "	1867.	A. Leitelt Bros. & Co., Supplies . . .	9 00
1875.					
Jan.	5.	Order No.	2065.	H. H. Chipman, Legal	14 00
Feb.	16.	" "	2424.	C. C. Comstock, Damages to Reservoir	6 00
					$290 79

Total amount paid on Construction $248,772 47

OPERATION OF WATER WORKS.

1874.					
Aug.	18.	Order No.	702.	Thos. Smith & Co., Tapping Mains .	$ 56 15
Aug.	26.	" "	751.	C. C. Comstock, Pumping	76 50
Sept.	1.	" "	779.	Schriver, Weatherly & Co., Tapping Mains	75 90
Sept.	1.	" "	810.	Thos. Smith & Co., Tapping Mains .	162 46
Sept.	8.	" "	885.	C. C. Comstock, Pumping	175 50

Sept.	29.	Order No.	1110.	M. V. Bentley, Oil	6 25
Oct.	6.	" "	1148.	Thos. Smith & Co, Tapping Mains .	56 14
Oct.	6.	" "	1151.	David C. Sawyer, Labor at Pumping Works	45 50
Oct.	6.	" "	1153.	W. G. Whittemore, Labor at Pumping Works	60 00
Oct.	13.	" "	1275.	A. Leitelt Bros. & Co., Supplies . . .	11 79
Oct.	13.	" "	1276.	" " use of boiler, &c.	32 88
Oct.	13.	" "	1280.	" " Pumping . . .	417 75
Oct.	20.	" "	1331.	C. C. Comstock, Pumping and Supplies	39 87
Oct.	29.	" "	1411.	Richmond & Backus, Assessm't Books	14 00
Nov.	3.	" "	1501.	John L, Shaw, Repair of Hydrants .	4 00
Nov.	10.	" "	1601.	W. G. Whittemore, Labor at Pumping Works	62 00
Nov.	10.	" "	1602.	David C. Sawyer, Labor at Pumping Works	39 25
Nov.	10.	" "	1603.	David C. Sawyer, Labor at Pumping Works	15 00
Nov.	17.	" "	1662.	Louis Deitz, Pumping	20 25
Nov.	17.	" "	1667.	Thos. Smith & Co., Tapping Mains .	80 72
Nov.	17.	" "	1670.	Butterworth & Lowe, Pumping . . .	150 00
Dec.	1.	" "	1757.	David C. Sawyer, Labor at Pumping Works	37 25
Dec.	1.	" "	1758.	David C. Sawyer, Labor at Pumping Works	10 00
Dec.	1.	" "	1759.	W. G. Whittemore, Labor at Pumping Works	54 00
Dec.	8.	" "	1865.	P. Coad, Labor on Valves	18 50
Dec.	8.	" "	1866.	Edward Walsh, Wood	12 00
Dec.	8.	" "	1868.	A. Leitelt Bros. & Co., use of Boiler and Supplies	91 41
Dec.	15.	" "	1975.	M. H. Clark & Co., Printing	6 50
Dec.	22	" "	2012.	G. R. Brush Co., Pumping	57 45
1875.					
Jan.	5.	Order No.	2080.	David C. Sawyer, Labor at Pumping Works	54 25
Jan.	12.	" "	2160.	Jas. W. Brown, Entering Assessments	6 00
Jan.	12.	" "	2189.	Schriver, Weatherly & Co., Tapping Mains	104 18
Jan.	12.	" "	2190.	W. G. Whittemore, Labor at Pumping Works	61 00
Jan.	19.	" "	2217.	W. H. Congdon & Co., Wood . . .	155 63
Jan.	26.	" "	2225.	James W. Brown, Entering Returns .	3 00
Jan.	29.	" "	2254.	M. H. Clark & Co., Printing	1 50

Feb.	9.	Order No.	2376.	W. H. Congdon & Co., Wood . . .	$152 50
Feb.	9.	"	" 2377.	David C. Sawyer, Labor at Pumping Works	60 00
Feb.	9.	"	" 2378.	W. G. Whittemore, Labor at Pumping Works	14 00
Feb.	9.	"	" 2383.	M. H. Clark & Co., Printing . . .	2 80
Feb.	9.	"	" 2392.	J. Van Der Sluis, Printing	4 80
Feb.	16.	"	" 2422.	White & Conant, "	1 40
Feb.	16.	"	" 2423.	A. Leitelt Bros. & Co., use of Boilers and Labor	250 00
Feb.	16.	"	" 2425.	W. H. Congdon & Co., Wood . . .	157 50
Feb.	16.	"	" 2429.	A. B. Turner & Co., Printing . . .	2 25
March	2.	"	" 2635.	Kingsbury & Bennett, Coal	299 08
March	2.	"	" 2636.	W. G. Whittemore, Labor at Pumping Works	8 00
March	2.	"	" 2637.	David C. Sawyer, Labor at Pumping Works	49 00
March	2.	"	" 2638.	E. F. Bradley, Labor at Pumping Works	101 00
March	2.	"	" 2640.	A. Leitelt Bros. & Co., use of Boiler,	25 00
March	9.	"	" 2691.	Samuel Taylor, Wood	46 50
March	9.	"	" 2692.	W. H. Congdon & Co., Wood	155 50
March	6.	"	" 2693.	P. Coad, Removing Snow	12 65
March	16.	"	" 2764.	Samuel Taylor, Wood	108 00
March	16.	"	" 2765.	" " "	147 00
March	16.	"	" 2768.	A. Leitelt Bros. & Co., Repairs . . .	172 18
March	16.	"	" 2769.	Vincent Sipple, Wood	96 00
March	16.	"	" 2770.	S. S. Bailey, "	78 00
March	23.	"	" 2827.	Samuel Taylor "	43 25
March	23.	"	" 2828.	S. S. Bailey "	71 75
March	23.	"	" 2829.	S. S. Bailey "	202 60
March	23.	"	" 2830.	Price & Baylies, Coal	[illegible]15 02
March	23.	"	" 1831.	L. H. Withey & Co., Wood	817 90
March	23.	"	" 2832.	M. V. Bentley, Oil	13 10
March	30.	"	" 2826.	A. Leitelt Bros. & Co., Heater and use	60 12
March	30.	"	" 2863.	S. S. Bailey, Wood	420 37
March	30.	"	" 2864.	Samuel Taylor, Wood	47 25
March	30.	"	" 2867.	Schriver, Weatherly & Co., Labor . .	8 25
March	30.	"	" 2869.	Foster, Stevens & Co., Supplies . . .	15 75
April	7.	"	" 2936.	Miles S. Youngs, Labor at Pumping Works	66 00
April	7.	"	" 2937.	David C. Sawyer, Labor at Pumping Works	56 00

April	13.	“	“	3042.	M. H. Clark & Co., Printing	14 00
April	20.	“	“	3081.	H. Christiansen, Repairing Pump	8 25
April	28.	“	“	3194.	Thos. Smith & Co., Tapping Mains	54 96
						$6,132 31
Due on account to May 1st						150 78
Due General Fund for Superintendence						383 00
					Total cost of operation	$6,666 09

GRAND RAPIDS HYDRAULIC COMPANY.

The Grand Rapids Hydraulic Company, organized by Act of the Legislature April 2nd, 1840, is the pioneer in the direction of water supply and has, from the summer of that year until now, to some extent provided water to portions of the city. It began its operations by laying wooden logs from springs along our hillsides, which provided pure water at such atitude that it could be generally distributed to the streets west of Division street. This simple enterprise at that early date was certainly of some value, and the flow of water given at the old National Hotel was quite a feature of comfort to the stage worn explorers of twenty-five years ago.

Tbe increased demand as year after year the city grew, was met by this Company by the extension of its lines of logs and the addition of sources of supply, until in 1857 a line of iron pipe was laid in Monroe street, and the works began to assume some importance to those whose wells were rendered useless by sewerage or surface water.

That much of the healthfulness of the young city was due to this supply of the purest spring water, so directly delivered, cannot be doubted.

In 1861 a brook flowing from great springs on the lands known as "The Penney Eighty" was incorporated into the supply, and with increased volume of water the company even then found that it could not reach many who were in need. In 1864 at the head of this brook the Company purchased land for a larger Reservoir and began the storage of water for the first time in the history of Grand Rapids. In 1870 an additional connection was formed, embracing magnificent hill-side springs north of Bridge street, owned by Messrs. Mangold & Kusterer, who had been for some time before this supplying many citizens of that vicinity. Still the pressing demand overtaxed the supply. The purity and peculiarly excellent quailities of this water for domestic purposes invited consumption, and the free penstocks liberally provided by the Company became the reliance for man and beast of a large population. In 1872 the Company undertook a larger enterprise in the construction of a well at their Reservoir, in imitation of the famous one which is the pride of Kalamazoo, The brick and iron work of this huge tube was sunk into the earth below the bottom of the old Reservoir, by dredging out the inside and allowing its great weight to press its iron foundations as low as the lowest water courses. The wall plastered inside and out with hydraulic cement thus becomes the recipient of water only from the deep gravel strata and excluding all surface water, is certainly as far as its capacity goes undeniably a perfect affair, and the Hydraulic Company upon its completion was enabled to extend its pipes and increase the usefulness of its works. A six inch main was laid from the well along Division street to Fulton and Monroe, and provisions made for future improvements. The works of the city with the great altitude of the reservoir and the strength of the mains, tower above the simpler appliances of the Hydraulic Company, but as the investment of the capital of private citizens in our midst and as the dispenser of a pure supply through long years until to-day, the Pioneer works are entitled to their place in the annals of water works in our city.

The Company has now in operation about eight miles of pipes.

REPORT

OF THE

CITY ENGINEER,

GRAND RAPIDS, MICHIGAN.

MAY FIRST, 1876.

REPORT

OF THE

CITY ENGINEER,

MAY FIRST, 1876.

OFFICE OF THE BOARD OF PUBLIC WORKS,
Grand Rapids, May 1st, 1876.

To the Honorable, the Board of Public Works of the City of Grand Rapids:

I herewith submit a report of the Public Works carried on under the direction of the Board since May 1st, 1875.

STREET IMPROVEMENTS.

The following street improvements have been completed:

Grading and Paving,	1885	Lineal Feet.
Grading, Graveling and Paving Gutters.	12737	" "
Grading and Graveling,	10317	" "
Paving Gutters,	1282	" "
Total,	26,221	Lineal Feet,=4 96.

Contracts have been made for the following improvements which are now in progress:

Grading and Paving,	11352	Lineal Feet.
Grading, Graveling and Paving Gutters,	16590	" "
Grading and Graveling,	924	" "
Grading,	1356	" "
Total,	30,222	Lineal Feet,=5 72 miles.

The paving is all of the kind adopted by the Board in 1874; wood blocks in the center and cobble stones on the sides of the streets, which, so far, appears successful and popular.

The total length of streets now opened in the city is over 131 miles, of which, counting those now under improvement as finished, are:

Graded and Paved with wood,	0.15	miles.
Graveled and Paved with wood and stone,	2.68	"
Graveled and paved with stone,	1.55	"
Graded and Graveled and Gutters paved,	21.56	"
Graded and Graveled,	29.50	"
Graded,	8.02	"
Un-improved,	67.66	"
Total,	131.12	"

BUILDINGS.

Barns have been constructed at Engine Houses No. 1, 3, 4, 5 and 6, on plans prepared by Grady and Waddell, Architects.

A fire proof vault has been constructed at the office of the Board of Public Works, for the safe keeping of the maps, records and papers of the Board, and of the Common Council.

FIRE RESERVOIRS.

Two brick reservoirs have been constructed for the use of the Fire Department. One on Quimby Street, between Plainfield and Coit Avenues; capacity 500 barrels. The other on Grandville Avenue opposite Prescott street capacity, 100 barrels. The former is supplied by springs, and the latter by a creek which is admitted into it.

SEWERS.

The amount of sewerage constructed during the past year has been much greater than usual, the total length being only 47 feet less than was constructed in the previous two years.

The proportion of large sewers has also been unusually great, which has increased the average cost per foot more than the uncommonly low prices of labor and materials have reduced it.

The total length constructed was 12149 feet and the total cost $28,192 26, making the average cost per foot, $2 32½.

The following table shows the length and sizes of the sewers constructed.

The one in Lyon street was to replace an old sewer which required lowering on account of the regrading of the street, and 250 feet of the one in Fulton street replaces an old one which never worked satisfactorily. The construction of the sewer in Williams and Ionia sts. renders 50 feet of the Spring street sewer of no further use and it has been closed up.

The total length of sewers now in use in the City is as follows:

Brick Sewers	32,119	lineal feet	— 6 439-5280	Miles
Clay Pipe Sewers	30,906	" "	— 5 4506-5280	"
Cement Pipe Sewers	2,680	" "	— 0 2680-5280	"
Wooden Sewers	8,621	" "	— 1 3341-5280	"
Total	74,326	" "	— 14 miles, 406 feet	

The following are the sizes as near as can be ascertained, and the lengths in feet of each size:

BRICK SEWERS.

10'-4"x6'-2" 358; 5'x6' 1164; 4'x5' 2689; 40"x60" 712; 36"x54" 20; 3'x4' 5117; 2'x3' 3327; 22"x33" 572; 24"x30" 1542; 20"x30" 3614; 20"x24" 3551; 18"x24" 6411; 16"x24" 2842.

CLAY PIPE SEWERS.

24" 358; 22" 367; 20" 1173; 18" 5569; 15" 6349; 12" 14790; 9" 2310.

CEMENT PIPE SEWERS.

18" 96; 12" 1701; 9" 513; 8" 370.

WOODEN SEWERS.

3'x4' 4328; 18"x24" 1635; 18"x18" 850; 12"x18" 834; 12"x12" 974.

LENGTH AND SIZES OF SEWERS CONSTRUCTED SINCE MAY 1st, 1875.

STREET.	FROM	TO	Length in Feet and Size in Inches.													Man Holes	Catch Basins.
			BRICK.						FIRE CLAY PIPE.						Total.		
			48x60	40x60	36x54	24x36	22x33	16x24	24	22	20	18	15	12			
Bartlett,	e line Sum.-st.	Cen. Ionia-st.											290	556	846	2	2
Bridge	e line Clinton-st.	w line Ionia-st.											587		587	3	6
Bridge	70'e of Front-st.	e Gut. Win.-st.											828	412	1240	4	4
Cherry	w line Union-st.	Cen Lagrave-st.				305			292	367	357	962	325	338	2946	9	19
Ful. & Mon'e.	e line Jeff. Ave.	e line Div.-st.						54			806	278			1138	5	4
Goodrich	e line Summit-st	Cen. Ionia-st.											290	551	841	2	2
Ionia & Will's	Cen. Prescott-st.	Cen. Spring-st	1274	712	20										2006	6	
Jeff. Avenue.	n. line b'k 1, Smith's Addi'n.	Cen. Cherry-st												403	403	1	
Lyon-st.,	w line Ionia-st.	w line Kent-st.				564									564	2	2
Prospect,	37' n of State-st.	Cen. Washington													480	2	
West Fulton,	w line Winter-st.	Grand River				510	572		66						1148	4	6
TOTAL,			1274	712	20	1379	572	54	358	367	1163	1240	2320	2260	12149	40	45

Notwithstanding the comparatively rapid extension of our system of sewers during the past three years, there still exists a great need of its further extension into large sections of the City which are now wet and unhealthy, as soon as an improved condition of business shall justify the large expenditure which will be required.

SUMMARY OF WORK DONE.

In the accompanying table will be found a list of all the improvements contracted by the Board since May 1st, 1875, with the name of the contractor and the cost for construction, and for engineering,' printing and assessment. Those marked * were in progress May 1st, 1875. From this table we deduce the following summary:

Total length of streets improved, 26,221 lineal feet.
" " " sewers built, 12,149 lineal feet.

TOTAL COST OF IMPROVEMENTS COMPLETED BY BOARD.

Grading and Paving		$10,038 07
Grading, Graveling and Paving Gutters,		35,498 90
Grading and Graveling,		11,203 62
Paving Gutters,		1,069 15
Sewers,		28,192 26
Buildings and Miscellaneous,		4,970 30
Total cost of completed work,		$90,972 30
Add payments made on work in progress,		43,413 75
" " " on Water Works construction		101,993 97
" " " " " " operation,		7,793 52
Total,		$244,173 54
Deduct payments previous to May 1st, 1875,	$27,816 31	
Due on Water Works const'n " "	25,750 63	
" " " " operat'n " "	533 78—	54,100 72
Total expended under direction of the Board,		$180,072 82

IMPROVEMENTS CONDUCTED BY BOARD OF PUBLIC WORKS, May 1st 1875 to May 1st 1876.

IMPROVEMENTS COMPLETED.

Grading and Paving.

STREET.	FROM	TO	LENGTH. Feet.	CONTRACTOR.	COST.		
					CONSTRUCTION.	ENGINEERING, ASSESSMENT AND PRINTING.	TOTAL.
Campau,	Pearl,	Lyon,	221	E. D. Hulbert,	$2306 00	$ 60 85	$ 2366 85
Lyon,	Campau,	Canal,	266	"			
Monroe	Waterloo,	Fulton,	1398	T. C. Brooks,	7389 72	281 50	7671 22
			1885		$9,695 72	$342 35	$10038 07

Grading, Graveling and Paving Gutters.

STREET.	FROM	TO	LENGTH. Feet.	CONTRACTOR.	CONSTRUCTION.	ENGINEERING, ASSESSMENT AND PRINTING.	TOTAL.
*Bostwick,	Bridge,	Lyon,	1076	Joel Collins,	$2967 00	$ 190 70	$ 3157 70
Bronson,	Canal,	Kent,	222	Charles Prange,	574 00	65 00	639 00
*Clancy,	Fairbanks	Cedar,	2110	Utes&Livingston	6736 05	176 15	6912 20
*Madison Avenue,	Cherry,	Hall,	6615	Patrick Grady,	14216 81	333 80	14550 61
Trowbridge,	Clinton,	Clancy,	1012	Charles Prange,	2181 64	89 80	2271 44
*Waterloo,	Cherry,	Wealthy Avenue,	1702	F. B. Gilbert,	7793 75	174 20	7967 95
			12737		$34,469 25	$1,029 65	$35498 90

Grading and Graveling.

STREET.	FROM.	TO.	LENGTH. Feet.	CONTRACTOR.	COST.		
					CONSTRUCTION.	ENGINEERING, ASSESSMENT AND PRINTING.	TOTAL.
*Carrier,......	235 ft. e. of Plainfield A	Union,.................	2965	Patrick Gill,......	$2338 00	$60 70	$2398 70
First, ...	Michigan, ...	Pine....................	1442	Geo. Stainford,	1030 29	86 60	1116 89
Hilton, ...	Prescott, ...	Rumsey,...............	1835	Patrick Grady,...	3117 08	115 10	3232 18
*Straight, ...	Bridge, ...	Butterworth Ave....	4075	Thomas&Enright	4195 10	260 75	4455 85
....	....	....	10317	....	$10680 47	$523 15	11,203 62

Paving Gutters.

Washington, ...	Jefferson Avenue......	Madison Avenue, .	1282	H. Wagemacker & Co.	$1004 55	$64 60	$1,069 15

Sewers.

Bartlett, ...	Summit, ...	Ionia, ...	846	Joel Collins, ...	$ 775 00	$ 75 40	$ 850 40
Bridge, ...	Clinton,....................	Ionia, ...	587	" "	1085 00	172 10	1257 10
Bridge, ...	Powers' Canal,...........	Winter, ...	1240	" "	1954 45	177 20	2131 65
Cherry, ...	Union, ...	Lagrave	2946	A. C. Sekell,....	6399 26	269 90	6669 16
Fulton & Monroe, ...	Jefferson Avenue.	Division, ...	1138	Joel Collins,....	2338 62	142 60	2476 22
Goodrich,..................	Summit,...	Ionia, ...	841	" "	791 65	73 20	864 85
Ionia & Williams, ...	Prescott, ...	Spring, ...	2006	T. C. Brooks,..	7235 83	769 00	8004 83
Jefferson Avenue, ...	N 1 lot 5, bk.1 Smith's A	Cherry, ...	403	Joel Collins......	475 00	61 10	536 10
Lyon,........................	Ionia,.......................	Kent, ...	564	L. Schneider, ...	1254 95	182 00	1436 95
Prospect, ...	State, ...	Washington, ...	430	T. C. Brooks,...	520 00	68 40	588 40
West Fulton, ...	Winter, ...	Grand River, ...	1148	A. C. Sekell,....	3094 00	282 60	3376 60
....	....	... .	12 149	....	$25,918 76	$2,273 50	$28192 26

BUILDINGS AND MISCELLANEOUS.

IMPROVEMENTS.	CONTRACTOR.	COST.
Barn at Engine House No. 1, ...	Chas. H. Peale & Co., ..	$1116 75
Barns at Engine Houses Nos. 3, 4, 5 and 6, ...	John Van Every, ...	2353 60
Reservoir in Grandville Avenue, ...	Leonhard Schneider, ...	190 00
Reservoir in Quimby Street, ...	Joel Collins, ...	420 00
Sidewalk on Leonard Street Bridge, ...	Ambrose Mitchell, ...	400 00
Vault in office of Board of Public Works, ...	Leonhard Schneider, ..	489 95
		$4970 30

Improvements now in Progress.

STREET.	FROM	TO	Length Feet.	Contractor.	Improvement.	Estimated Cost.
Bridge, .	Powers' Canal,	Broadway....	1044	T. C. Brooks,	Grading & Paving	$ 5000
Canal, ...	Pearl	N. Limits, ...	9273	Leonard & Sterling,	" "	62000
Lyon, ...	Canal	Division, ...	1035	John Collins,	" "	5000
Bartlett, ..	Division, ...	Waterloo, ...	2569	Utes & Livingston	G. G. & Pav. Gut.	7500
Cedar ...	Clancy, ...	College Ave,	1650	" "	" " "	5050
Cemetery,	Fulton, ...	Fountain, ...	756	Joel Collings,	" " "	1300
Clinton, ..	176 ft. s of Trowbri'e	Mason, ...	1876	P. Grady, ...	" " "	5500
Coldbrook,	Canal	Coit Avenue,	1572	Leonard & Sterling	" " "	3000
Goodrich,	Division....	Waterloo, ...	2878	T. C. Brooks,	" " "	8000
Ionia, ...	Evergreen .	Cherry, ...	4578	P. J. Britton,	" " "	10300
Ransom, ..	Fountain, ..	Lyon, ...	711	John Collins,	" " "	1700
Indiana, ..	Bridge, ...	Jackson, ...	924	" "	Grad'ng & Gra'ng	2300
Front	Bridge, . .	Pearl, ...	1356	Powers & Converse,	Grading, ...	2500
			30222			$119 150

On these improvements payments have been made on estimates to the amount of $43,413 73

Water Works.

Owing to the want of funds, nothing was done towards the extension of the Water Works until August 7th, when, the Common Council having authorized an additional loan of $100,000, the Board received proposals for furnishing and laying about 6 miles of pipe, including stop valves, hydrants and special castings. Following is a schedule of the bids received.

Schedule of Proposals for Water Pipe, Aug. 7th, 1875.

	Farrington & Branch.					Charles Mc-Ritchie	Smith & McEwan.			Thaddeus C. Brooks.			Cregier, Clark & Co.
	Stave.	Wyckoff.		Cast Iron.		Cast Iron.	Cast Iron.		Logs.	Cast Iron.		Logs.	
		Strong.	Light.	Strong.	Light.	Strong.	Strong.	Light.		Strong	Light.		
20 in. pipe.	3 00	...	....	4 37	4 18	....	....	....	....	....	....	.....	....
14 " "	. .	2 13	1 85	2 49	2 42	2 30	....	....	.....	....	2 15	. ..	.. . .
12 " "	....	1 58	1 30	2 09	1 97	2 05	2 04	...	.....	1 95	....	... .	....
10 " "	....	1 45	1 17	1 54	1 50	1 51	....	....	.....	1 49	1 33	.....	....
8 " "	....	1 10	0 97	1 31	1 22	1 30	1 32	1 28	.....	1 27	1 06	... .	....
6 " "	....	0 89	0 75	0 97	0 87	0 93½	0 92	0 83	0 53	0 94	0 83	0 54	... .
4 " "	....	0 63	0 57	0 68	0 58	0 67	0 63	0 59	0 43	0 65	0 58	0 38	....

20 inch valves,	$240	....	....	....	not set.
14 " "	133	$110	$132	$125	$ 125
12 " "	84	90	105	90	70
10 " "	64	70	70	57	55
8 " "	51	52	52	47	48 00
6 " "	39	42	38	34	33
4 " "	27	80	27	24	20
HYDRANTS					
Single,	50	50	....	50	45
Double,	54	55	45	....	60
Mathews Triple,	75	....	....	52.-75.6" Stem	....
Flowers Duplex,	...	....	72	....	....
Lowry,	90	....	90	75	....

Cregier, Single, with independent nozzle valves. 75

" 90 Double, " " " " ....

" 70 " without " " " ....

Special casting,	8½c.	5c.	4½c.	4c.
Extra Exc.	40c.	50c.	50c.	40c.

Contracts were entered into with Farrington & Branch for Wyckoff pipe 12 and 14 inches in diameter, with Thaddeus C. Brooks for cast iron pipe, 4, 6, 8 and 10 inches in diameter, and with Smith & McEwan for logs 4 and 6 inches bore.

These contracts have all been completed and the amount of work done is as follows:

1317	Lineal feet,	14 inches,	Wyckoff Pipe.
2210 70	“ “	12 “	“ “
1779	“ “	6 “	“ “
519 75	“ “	10 “	Cast Iron Pipe,
3227 40	“ “	8 “	“ “
6917 21	“ “	6 “	“ “
4808 65	“ “	4 “	“ “
8529 25	“ “	6 “	Logs.
1141 14	“ “	4 “	“
1		14 inch	Stop Valves.
3		12 “	“ “
1		10 “	“ “
4		8 “	“ “
18		6 “	“ “
12		4 “	“ “
53			Lowry Hydrants.
15			Mathews “

The streets on which these pipes were laid are marked * in the list of water mains annexed to this report.

The total length of pipe laid during the year was 30450 feet, or including the pipe under the river, the pipes at the setling basin and the supply pipe from the basin to the engine house, 33311 feet=6 3-10 miles.

Of the 6 inch Wyckoff pipe laid in Shawmut Avenue, 770 feet was old pipe taken from Pearl street bridge, after the pipe under the river was completed. With the exception of this line no Wyckoff pipe was laid less than 12 inches in diameter, the great reduction in the price of cast iron having removed the chief reason except for large sizes, which governed the Board in adopting this pipe in 1874.

The logs laid are only on the higher levels where the pressure seldom exceeds ten pounds per square inch. They were adopted from motives of economy in order to extend the distribution as far as practicable into a neighborhood of residences which promised to be large consumers of water.

The Mathews Hydrants have 6 inch stand pipes and 2 hose and 1 steamer connections. They were set on the principal business streets in place of two-nozzle Ludlow hydrants, of which 7 have been re-set on the pipe laid this year, and 8 are on hand to be re-set on future extensions.

A short experience with the Lowry Hydrants set in 1874, satisfied the Board that the public interest would be subserved by a radical change in the action of the valves. The work was satisfactorily done by Messrs. Leitelt Bros. & Co., and the proportion of the cost to be paid by the city and contractors was settled by arbitration.

The total length of pipe now laid in the city is 99778 feet, or 18 9-10 miles, of which all but 5012 feet, or less than one mile, is available for tapping. There are 111 stop valves, and 199 hydrants, of which 171 are Lowry, 15 Mathews and 13 Ludlow.

Pipe Across Grand River.

The connection between the east and west sides of the river has been completed by the laying of the 12-inch wrought iron pipe described in the last report, in a trench cut in the rock bed of the river. Two additional lengths were manufactured by A. Leitelt Bros. & Co., making the total length 784 feet. All bids received for digging the trench and laying the pipe being considered too high, the work was done by the day, under the superintendence of Silas M. Pelton, at a saving of several hundred dollars. The pipe was put together on trestles, the joints being packed with bass-wood gaskets, and the entire length lowered into the trench at once by jack-screws.

Reservoir.

The outer slopes of the reservoir have been sown with grass-seed this spring to prevent wash. The reservoir is in good order and has shown no signs of leakage since its completion.

Engine House.

Since the last report the engine house has been accepted, and settlement made with the contractors; flooring and wainscotting put in the engine room; the engine room painted and the floor oiled; a lightning rod put up on the chimney, and the grounds on the east and south sides of the building filled up to the new grade of Canal street with soil selected from the excavation for the settling basin.

When the improvement of the street is completed the grounds should be sodded or sown with grass-seed, and enclosed with a neat fence.

A shed should also be built to protect the fuel from the weather, and a more convenient means of communication made between the wood yard and the boiler room.

Pumping Machinery.

The pumping machinery has been completed and settled for. The engine commenced pumping into the reservoir on the 9th day of June 1875, and has since furnished the city with its entire supply.

The engine is of the horizontal, direct acting, expansive, condensing type, with steam cylinder thirty-three inches in diameter, and six feet stroke, with balanced, double beat poppet valves set on the top side of the cylinder. The valves are fitted with a variable cut-off of Mr. Turner's invention, arranged so as to cut off at any point of the stroke.

The engine is built on an ornamental moulded frame, 48 feet 5 inches long, by 20 inches deep, and 5 feet 2 inches wide, which is narrowed at the back end to about 3 feet 8 inches for 10 feet of the length to receive the main pump.

The air pump is worked with pendulum shaft, lever and links from the main cross-head, and together with the common jet condenser maintains a vacuum equal to 26 inches of mercury.

The main pump is 14½ inches in diameter and 6 feet stroke, connected to the back end of the piston rod with light cross-head and slides between it and the steam cylinder. It is a double acting piston pump with rubber valves, each suction and delivery valve being composed of two separate valves, and from their arrangement in side pipes on each side of the water cylinder they are easy of access for repairs. It is provided with vacuum and air chambers, the lower part of the latter being of cast iron, which, while serving as a solid foundation for air chamber, also forms a well for the pump to draw the from. The air chamber is 3½ feet in diameter and 15 feet high.

The fly wheel is 14 feet in diameter and weighs 1,700 pounds.

Steam is generated in one externally fired tubular boiler 16 feet long and 6½ feet in diameter, with 90 four-inch tubes in it.

To the front end of the boiler is rivetted a circular heater or water leg, extending from the bottom one-third of the circumference upon each side, by about 2 feet 6 inches long, and having three inches water space. This serves the double purpose of a heater and smoke box, and at the same time dispenses with a brick arch over the fire. The boiler has a handsome heavy fire front, with six convex air tight doors, and strong flanges inside to receive brick work.

The engine is estimated to be capable of delivering at sixteen revolutions per minute 2,300,000 gallons in 24 hours into the reservoir, the water line of which, when full, is 148½ feet above the pumps.

The Worthington engine, which supplied the city previous to the completion of the new engine, has been removed from the temporary engine house, and is now undergoing repairs.

The house has passed by agreement into the possession of the owner of the land on which it stood.

Settling Basin.

When the engine first commenced running, it took its supply of water from Coldbrook creek by means of a temporary pipe 20 inches in diameter, made of pine staves banded with iron, which took the water from the creek on a parcel of land leased of Richard Long, on the east side of Canal street, and brought it into the settling well adjoining the engine house. As the water of this creek is frequently muddy, and otherwise somewhat objectionable, this arrangement was only intended for temporary use until a connection could be made with Carrier creek, the proposed source of supply. This creek furnishes about 818,000 gallons per day, sufficient for present consumption, but in its natural state, either constant pumping would be reqnired, or the entire flow while the engine was not pumping would be lost. It became necessary therefore to provide means for storing the water. This has been accomplished by the construction of a Storage Reservoir or Settling Basin.

The site for this basin, including ten acres of land, was purchased of Richard Long and others for $15,000, and includes an abandoned mill pond, one of the oldest in this section of the country. Carrier and Coldbrook creeks run through the grounds, the mouth of the former being on the present site of the basin.

The plans for the basin were prepared by the City Engineer, and the contract for its construction was awarded to Peter Granger on the 7th day of August. The bids ranged from $6,652 to $10,969. The work was complered in the Fall as far as the specifications provided, which was sufficient to bring it into use.

The basin is made of a form adapted to the shape of the ground, having seven sides, the respective lengths of which at the bottom of the basin are 356', 33', 84'5", 169'8", 69'2", 172'5", 88'6".

The area at the bottom is 51 717 square feet, and at the proposed water line 80 636 square feet.

The two northeasterly sides are entirely in excavations the others partly in excavation and partly in embankment. The entire bottom is an impervious clay. The embankment is 12 feet wide on the top, the outer and inner slopes are each two horizontal to one vertical. The inner slope is broken by two berms, each three feet wide, at 7 and 13 feet above the bottom, for convenience in passing around the edge of the water. The top of the embankment is 15 feet above the bottom of the basin or three feet above the proposed water line. The embankment is formed of material selected from the excavation, which, being mostly clay, required no puddling. In the south-west corner there is a pocket of lighter material in the original soil through which roots appear to have run to the new channel cut for Coldbrook creek, and caused a small leak. This corner will have to be lined with puddle.

The inner slopes are not paved. The paving was omitted for several sufficient reasons: 1st, there was no money to pay for it; 2d, if the paving had been done, the basin could not have been brought into use before the middle of the coming summer; 3d, it was difficult to determine beforehand what material would be met with, and how much and what character of protection the slopes would require.

Observations of the effect of the water upon the slopes during high winds show that it would be advisable to pave a portion if not all of the slopes with dry stone to prevent the water from becoming turbid by the washing of the clay, as well as to guard against possible accident from the operations of muskrats. This should be done if possible, during the present season.

A high, tight fence should also be built around the basin to break the force of the wind, and prevent its being made a place of resort for bathing.

The water of Carrier creek is admitted to the basin by an inlet pipe of cast iron, 20 inches in diameter and

63½ feet long, on the east side of the basin. The joints are protected by small piers of masonry. A similar inlet pipe is provided on the south side of the basin for admitting the water of Coldbrook creek temporarily in case of necessity, or for extension to the head waters of that creek, whenever the supply from Carrier creek becomes insufficient. Each inlet pipe is provided with a 20-inch valve, over which is built a chamber of brick masonry, with man-hole in the top, and at the upper end of each pipe is a chamber of plank, 3½'x3½' and 8 and 10 feet deep, into which the water from the creek flows.

The outlet of the basin is a mass of masonry, of an extreme length of 50 feet, and an extreme width of 23 feet, and a depth varying from 3 to 18 feet.

The water passes from the basin through a channel 4 feet wide and 32 feet long, between retaining walls into a chamber 4'x13' and 14 to 16 feet deep. There is a fall of one foot in the bottom of this channel from the basin to the chamber.

Near the west end of the channel is a set of three screens of copper wire ⅛ inch in diameter, and ½ inch mesh, one above the other, having a total height of 14 feet and width of 4½ feet.

The frames of the screens are held by grooves 3 inches wide, and 3 inches deep cut into blocks of Joliet stone, built into the bottom and side walls of the channel. The screens are raised by a chain attached to hooks on the frames.

Through the west wall of the chamber, near its north end, the 20-inch supply pipe is built, passing through a dry valve chamber 4x6 feet and 14 feet deep, in which is set a 20-inch valve. The bottom of the pipe is one foot above the bottom of the basin, thereby avoiding the drawing of the sediment. Near the south end of the chamber a drain one foot square passes through the wall into a waste chamber 4 feet square and 16 feet deep.

The bottom of the drain is one foot below the bottom of the basin, and by it the entire basin can be emptied when necessary. Above the drain are two overflows, the lower 2 feet square, the upper 4 feet wide and 2½ feet high. These openings are intended to keep the water line at 6 or 12 feet above the bottom of the basin, as may be necessary. The drain and lower overflow are closed by cast iron gates with composition faces, moved by rods which rise to the top of the masonry.

The water from the waste chamber is drawn off through a sewer of fire-clay pipe, 2 feet in diameter and 76 feet long, which passes under the supply pipe into the creek.

The valve and waste chambers are separated by a wall 3 feet thick, through which a 3-inch sewer pipe drains the former into the latter.

The coping of the entire structure, the faces of the drain and overflows, and the bottom of the waste chamber, are of dressed Joliet stone; the rest of the masonry is rubble laid in cement mortar, and the bottom is paved with cobble stones.

To divert Coldbrook creek from the site of the basin, a new channel was cut which passes over the supply pipe and sewer. To protect these a frame dam was built a few feet below the pipe, which raises the water to a sufficient height. This temporary arrangement was adopted in the hope that the Council would adopt measures to divert the creek through a sewer down Coldbrook street to the river, which would not only remove all possible danger of injury to the pipe and basin, but also enable the Board to fill up and improve the lands adjoining the basin, and sell such as may not be needed for its purposes. If this should not be done it will be necessary to protect the pipe and sewer with masonry.

Another frame dam is built across the creek just below the inlet pipe, to divert the water of the creek into the basin when nesessary, and a third over Carrier creek.

The total cost of the basin to date, including work done outside of the contract is $8,166.37.

The work was done under the faithful and competent superintendence of Wm. Thornton Esq., Assistant Engineer.

The basin is calculated to hold 12 feet of water, and with that depth will contain 5,898,459 gallons. It answers the double purpose of storing the water which would otherwise be lost while the pump is not running, and allowing the water to deposit any sediment it might contain.

Supply Pipe.

The supply pipe from the basin to the engine house is 1,993 feet long, of which 133 feet is cast iron 20 inches in diameter, and 1,860 feet is made of pine staves, 3 inches thick and banded with wrought iron. The pipe is made in sections 8 feet long, each section tapering from 22 inches in diameter at one end to 20 inches at the other. Six inches in length on the outside of the small end and the inside of the large end are beveled off to a thickness of one inch, and the connection made by driving the small end of each pipe tightly into the large end of the adjoining one. The joints of the staves are cut to the radius of the circle, and the outside of each pipe is turned off, and strengthened by seven bands 3-16 inch thick and from 1 to 1½ inches wide, usually 14 inches between centers, rivetted and driven on from the small end.

The entire outside of the pipe is thoroughly coated with pitch. The pipe was manufactured by Powers & Walker for $1.25 per foot measured in the ground, and laid by Smith & McEwan for 54 cents per foot.

Supply of Water.

The average daily flow of Carrier creek is about 818,000 gallons. The report of the engineer of the pumping works shows that the daily consumption is now about 500,000 gallons. As the consumption is likely to increase rapidly it evidently must soon reach the limit of the supply. It is true that at any time Coldbrook creek can be turned into the basin, so that there is no danger of a water famine, but the water of this creek is exposed to contamination in its flow through portions of the city, it is frequently muddy, and during the summer season especially, is not of such quality as is desirable for a permanent supply for domestic use. Measures must therefore soon be taken for laying a pipe from the basin to a point on the creek, half a mile east of the city limits, where pure water can be obtained, above the influences of dwellings and the outlet of Reed's Lake, to the amount of about 1,000,000 gallons per day. As this would cost several thousand dollars, it might be well first to ascertain whether the flow of Carrier creek cannot be increased by laying drain pipes to collect the springs at its head and thus saving the water which is now absorbed in the mucky soil and carried off by evaporation. This would cost but a few hundred dollars and would probably result in a considerable increase of the supply.

COST OF WATER WORKS.

The total expenditure for construction of the Water Works to May 1st, 1876 is as follows :

	Since May 1st, 1875.	PREVIOUS.	TOTAL.
Real Estate,	$ 15,312 50	$ 30,050 00	$ 45,362 50
Pipe System,	52.592 54	122,690 69	175,283 23
Pipe under river,	2,616 59	2,004 75	4,621 34
Connections with pumps,	....	364 37	364 37
Reservoir,	3,264 38	51,401 88	54,666 26
Settling basin and supply pipes	12,571 23	....	12,571 23
Engine house, temporary	20 00	250 39	270 39
" " Permanent	3,548 36	21,018 06	24,566 42
Pumping Machinery, "	7,284 56	14,181 81	21,466 37
" " Temporary	....	2,331 75	2,331 75
Meters	825 62	....	825 62
Hose Heads,	....	600 00	600 00
Engineering & superintendence	3,438 65	2,972 47	6,411 12
Printing and Advertising	40 05	152 50	192 55
Expenses of Loan,	189 69	463 01	652 70
Miscellaneous,	289 80	290 79	580 59
Total,	$ 101,993 97	$ 248,772 47	$ 350,766 44

Maintenance and Operation of Water Works.

Tho total receipts of the Water Works Fund have been as follows:

	Previous to May 1st, 1875.	Since May 1st, 1875.	TOTAL.
From sale of Bonds, ...	$ 240,084 91	$ 101,975 61	$ 342,060 52
" Bonds paid to Farrington & Branch, ...	10,000 00	....	10,000 00
" private parties for pipe laid	....	171 58	171 58
Total, ...	$ 250,084 91	$ 102,147 19	$ 352,232 10
Expenditures for construction,	$ 248,772 47	$101,993 97	$350,766 44

Water Works Income Fund.

RECEIPTS.	Previous to May 1st. 1875.	Since May 1st, 1875.	TOTAL.
From permits, ...	$ 1,060 00	$ 1,250 10	$ 2,310 00
" Water Rates, ...	132 61	7,600 52	7,733 13
" Frontage Tax, ...	....	3,064 37	3,064 37
Total, ...	$ 1,192 61	$ 11,914 89	$13,107 50
Operating expenses, ...	$ 6,132 31	$ 7,793 52	$ 13,925 83
Interest on Bonds, ...	17,637 33	26,280 00	43,917 33

The expenditures for maintenance and operation since May 1st, 1875 have been as follows:

For Pumping—Wages	$2,167 57		
Labor, ...	468 27		
Fuel, ...	2,967 46		
Oil, ...	45 73	=	$5,649 03
For Repairs,—Engine House	129 55		
Engine, ...	172 20		
Pipes, ...	70 67	=	372 42
For tapping Mains and setting Meters, ...			788 25
" Clerical and Office expenses, ...			676 96
" Rent and Taxes, ...			124 13
" Printing and Binding			45 10
" Freight and Cartage, ...			59 74
" Sundries, ...			77 89
Total, ...			$ 7,793 52

The receipts of the Works since they were opened have fallen short of paying the running expenses by $818.33, but during the past year the receipts have exceeded the expenditures by $4,121.31.

It may reasonably be expected that during the coming year the receipts will amount to $18,000, and that the expenditures will not exceed $10,000, leaving a balance of $8,000 to apply on the interest account.

Number of Permits for tapping issued since May 1, 1875,	257
“ “ “ “ “ “ previous to “ “	216
Total number issued..................................	473
Number Cancelled,..................................	11
Number now in force,..................................	462

Heretofore the tapping of the street mains has been done by Messrs. Tho's Smith & Co., and Schriver, Weatherly & Co., under licenses from the Board, but the Board has directed that hereafter this work shall be done by some one in their immediate employ, who shall also inspect all plumbing.

Licenses for general plumbing have been granted during the year to Voris & Wright, John A. Walkeley, A. Leitelt Bros. & Co., and Sproule & McGurrin.

Thirty-eight meters have been purchased during the year, making the total number 43, of the following sizes:

Ball & Fitts,	2 1½-inch,	6 1-inch,	13 ¾-inch,	16 ⅝-inch.	Total, 37.
Worthington,		2 “		4 “	Total, 6.

One of these meters was the means of discovering leaks on a single service, through which nearly 18,000 gallons of water were being wasted daily.

Operation of the Pumping Works.

Mr. Demetrius Turner, Engineer of the Pumping Works, makes the following report of the operations of the works:

Commenced pumping with the new engine on the 9th day of June 1875, and run until Dec. 31 without keeping any record, but kept the reservoir full to twenty feet, consuming 530 cords of wood.

Record of Engine from January 1st to Arpil 30, 1876.

MONTH.	Time Run.	No. of Revolutions.	Gallons Pumped.	Daily Average.	Cords of Wood consumed.	Cost of Wood.
	h.-min.					
January, ...	150-30	145,346	14,534,600	468,858	76½	$ 229 50
February...	143-10	146,481	14,648,100	505,107	76	228 00
March	102-05	143,561	14,356,100	463,126	88	264 00
April, ...	184-10	192,091	19,209,100	640,303	67⅜	202 12
Total, ...	579-55	627,479	62,747,900	518,578	307⅞	$ 923 62

The engine is estimated to pump 100 gallons at each revolution.

Total number of days pumping......................	107
Average time per day "	4 h. 50 m.
Cost of wood to raise 1,000,000 gallons 160 feet high....	$14 72
" " " 100 "	9 20
Average number of gallons pumped for 1 cord of wood,	203,810
" " " " 1 cent for wood,	679

The wood used was of very inferior quality.

Consumption of Water.

Assuming the population of the city to be 30,000, the average daily consumption of water for each inhabitant during the first four months of 1876 has been 17⅓ gallons, and for each tap 1123 gallons. This is very much below the amount that will be consumed during the warm summer months, when the large number of street sprinklers attached to the works will be in use. The increased consumption in April was owing to the large amount used in blowing off from the pipes the mud which had accumulated from the Coldbrook water.

Quality of Water.

Previous to June 9th, 1875, water was taken from Grand River, and from June 9th, 1875, to Feb'y 26th, 1876, from Coldbrook. The supply from both these sources, at the points where it was necessary to take it, was objectionable for domestic use, though every possible measure was taken to protect it from contamination, the creek having been thoroughly cleaned out nearly to its source. Since Feb'y 26th the supply has been taken from Carrier creek, which furnishes the best water that can be obtained in the vicinity of the city.

Tables accompanying this report show the streets in which water pipes are laid and the kind of pipe, the location of all hydrants and stop valves, the contents of the Reservoir for each foot of depth, and the items of expenditure for construction and maintenance of the Water Works during the year.

Respectfully submitted.

E. W. MUENSCHER,
Engineer.

LIST OF WATER MAINS.—May 1st, 1876.

EAST SIDE.

STREET.	FROM.	TO	Size.	LENGTH.			
				Cast Iron.	Wyckoff	Logs.	Total.
			Inches	ft. in.	ft. in.	ft. in.	ft. in.
Barclay,	Bridge,	Bronson	14	3-4	513-4		516-8
* "	Bronson	Lyon	4	3-4		546-8	550-0
* "	Fountain	Fulton	4	824-7			824-7
* Bostwick	Fountain	Lyon	4	689-2			689-2
Bridge,	Canal	Ottawa	12	605-0			605-0
"	Ottawa	Coit	12	27-7	1503-0		1530-7
"	Coit	Barclay	14	2-2	182-3		184-5
"	Barclay	Lafayette	10	519-9			519-9
Bronson	Barclay	Lafayette	14	2-2	498-7		500-9
* "	Lafayette	Union	6	19-1		1972-11	1992-0
Campau,	Pearl	County jail	4	7-7	435-7		443-2
Canal,	Pearl	Bridge	10	1496-0			1496-0
"	Engine House	Leonard	12	5-6	825-11		831-5
"	Leonard	R., S. & Co's. Mill	8	22-1	2136-1		2158-2
"	R. S. & Co's. Mill.	North limits	6	4-4	431-8		436-0
*Cherry	Summit	Ionia	8	902-0			902-0
"	Jefferson	Lafayette	8	5-4	652-4		657-8
* "	Lafayette	Paris	8	1665-0			1665-0
*Clancy	Bridge	Hastings	6	4-5		663-7	668-0
*Clinton	Bridge	Hastings	6	603-5			603-5
* "	Hastings	Fairbanks	6	5-5		1140-0	1145-5
Coit Avenue,	Bridge	Hastings	14	3-4	600-3		603-7
* "	Hastings	Trowbridge	6	8-5		566-7	575-0
Division	Bridge	Cherry,	12	28-5	3928-9		3957-2
* "	Cherry	Wealthy	12	19-5	1286-7		1306-0
Erie,	Canal	Leitelt's Shops	4	181-0			181-0
*Fountain	Division	Barclay	4	1151-5			1151-5
* "	Lafayette	Grand	6	19-3		2530-7	2549 10
Fulton,	Division	Prospect	10	21-10	2052-4		2074-2
Hastings	Coit	Livingston	14	2-2	403-0		405 2
Huron,	Canal	Butterworth	4	294-0			294-0
Ionia,	Pearl	Oakes	6	20-11	2081-1		2102-0
* "	Oakes	Cherry	6	475-4			475-4
Jefferson Ave	Fulton	Wealthy	6	19-6	2615-9		2635-3
*Kent,	Lyon	Bridge	6	1140-4			1140-4
"	Bridge	Trowbridge	6	8-4	1160-5		1168-9
* "	Trowbridge	Mason	6	1701-0			1701-0
Lafayette,	Bronson	Lyon	14	2-2	549-3		551-5
"	Lyon	Fulton	8	8-8	1565-9		1574-5
"	Fulton	Cherry	4	7-7	1136-3		1143-10
*Lagrave,	Fulton	Maple	6	1784-11			1784-11
Ledyard Al'y	Pearl	Rear of block	6	2-2	170-0		172-2
Leonard,	S. Canal	N. Canal	12	3-3	33-11		37-2
* "	N. Canal	Plainfield	12	8-0	896-8		904-8
Livingston	Reservoir	Newberry	20	272-3			272-3
"	Newberry	Hastings	14	6-6	1691-4		1697-10
Louis,	Waterloo	Campau	4	2-2	427-2		429-4
Lyon,	Nelson, Matter & Co	Canal	6	445-0			445-0
"	Canal	Ottawa	10	15-5	582-2		597-7
"	Ottawa	Division	10	508-5			508-5
"	Division	Lafayette	10	16-5	1660-10		1677-3
"	Lafayette	College	14	8-1	1308-11		1317-0

LIST OF WATER MAINS.—May 1st, 1876.

EAST SIDE.

STREET.	FROM.	TO	Size.	LENGTH.			
				Cast Iron.	Wyckoff	Logs.	Total.
			Inches	ft. in.	ft. in.	ft. in.	ft. in.
Mason	Reservoir	Ottawa	16	70–10	894–8	....	965–6
"	Ottawa	Canal	12	9–11	601–6	....	611–5
Monroe	Pearl	Ottawa	10	692–0	....	....	692–0
"	Ottawa	Division	12	801–4	....	....	801–4
Ottawa	Monroe	Newberry	12	4254–3	....	....	4254–3
"	Newberry	Mason	12	9–5	572–2	....	581–7
"	Mason	Engine house	16	88–3	1524–5	....	1612–8
Pearl	Division	Grand River	6	28–10	1536–6	....	1565–4
*Prospect	Fulton	Lyon	6	291–1	....	1307–11	1599–0
*Ransom	Fulton	Fountain	4	823–8	....	....	823–8
* "	Bronson	Bridge	4	4–4	....	594–4	598–8
*Sheldon	Fulton	Oakes	6	859–7	....	....	859–7
*Summit	Cherry	Bartlett	8	660–5	....	....	660–5
*Washington	Lafayette	College	4	1319–9	....	....	1319–9
Waterloo	Monroe	Fulton	8	11–3	1037–9	....	1049–0

WEST SIDE.

Allen	Summer	Winter	8	3–3	291 -2	....	294 -5
Bridge,	Front	Stocking	12	28–6	2000 -9	....	2029–3
Broadway	Bridge	Eighth	12	19–8	2847 -3	....	2866-11
Eighth	Broadway	Front	12	9–4	930 -8	....	940 -0
Fifth	Broadway	Seward	6	8–8	863 -6	....	872 -2
Front	Bridge	Shawmut	6	19–6	1650 -7	....	1670 -1
Jefferson	Bridge	Sibley	4	10–10	1308 -5	....	1319 -3
Pearl	Front	Grand River	6	3–3	93–8	....	96 -11
Scribner	Bridge	Eighth	6	17–4	2821 -8	....	2839 -0
"	Eighth	Webster	8	20–7	4217 -9	....	4238 -4
*Shawmut	Front	Jefferson	6	16–6	1779 -0	....	1795 -6
Summer	Bridge	G R & I R R	4	11–11	2147 -7	....	2159 -6
Third	Broadway	Seward	4	6–6	817 -2	....	823 -8
Winter	Allen	Shawmut	4	5–5	469 -0	....	474 -5

LIST OF WATER MAINS May 1st, 1876.

Not Available for Tapping.

STREET.		SIZE.	LENGTH.				
			Cast Iron.	Wro'ght Iron.	Wyckoff	Stave Pipe	Total.
		in	ft. in.	ft. in.	ft. in.	ft in	ft. in.
Allen	Blow off	8	1-1	....	61-2	......	62-3
*Coldbrook	Settling Basin to Eng. H	20	132-10	....	....	1860-0	1992-10
Engine House	Supply Pipes	20	72-1	....	....	......	72-1
Erie	Branch to Leitelt's Pump	4	19-0	....	....	......	19-0
Front	" " Brush Factory	6	1-1	....	44-5	......	45-6
"	" " Powers' Pump	4	1-1	....	44-2	......	45-3
"	" " Star Mills	4	1-1	....	55-10	......	56-11
GrandRiv'r	Canal to Front	12	1-2	784-0	40-9	......	825-11
Huron, ...	Branch to Butterworth's	4	30-6	....	....	......	30-6
Livingston	Under Reservoir Bank	20	77-3	....	....	......	77-3
Lyon, ...	Blow off	6	24-0	....	....	......	24-0
"	Br'nch to Nelson&Matter	4	42-0	....	....	......	42-0
Mason	Under Reservoir Bank	16	109-0	....	....	......	109-0
"	Ionia to River—Waste	12	2-8	....	1039-9	......	1042-5
Newberry	Branch to Comstock's Pipes.	12	7-0	....	....	......	7-0
" ...	" " " "	4	32-7	....	....	......	32-7
*Settling Basin,	Carrier Creek Inlet.	20	63-6	....	....	......	63-6
* " ...	Coldbrook Creek Inlet	20	63-6	....	....	......	63-6
....	Branches to Hydrants	6	400-6	....	....	......	400-6

Total Pipe Laid.

	20"	16"	14"	12"	10"	8"	6"	4"	TOTAL.
Cast Iron.......	681-5	268-1	29-11	5840-5	3269-10	3299-8	7932-0	5469-6	26791-0
Wrought Iron..	....	....	....	784-0	....	......	....	... ...	784-0
Wyckoff	......	2419-1	5746-11	16507-8	4295-4	9962-0	15248-3	6841-5	61020-5
Logs...........	....	....	....	......	....	....	8181-7	1141-0	9322-7
Stave.........	1860-0	.....	....	....	....	....	....	......	1860-0
TOTAL	2541-5	2687-2	5776-10	23132-1	7565-2	13621-8	31362-0	13451-8	99778-0

= 18.9 Miles.

LIST OF STOP VALVES.

STREET.	LOCATION.	PATTERN.	SIZE. inches.
Barclay	South Line Bridge St.	Lowry	14
* "	North " Lyon "	Flowers	4
* "	" " Fulton "	Eddy	4
*Bostwick,	South " Lyon "	"	4
Bridge, East	West " Division St.	Lowry	12
"	" " Coit Ave.	"	12
* "	East " Barclay St.	Eddy	10
Bridge, West	" " Front "	Lowry	12
"	" " Summer "	"	12
"	West " Broadway St.	"	12
"	" " Stocking "	"	12
Broadway	North " Bridge "	"	12
"	South " Eighth "	"	12
*Bronson	East " Lafayette "	Flowers	6
* "	West " Union "	"	6
Canal,	South " Lyon "	Ludlow	10
"	" " Bridge "	"	10
"	At Engine House,	Lowry	12
"	North Line Leonard St.	"	6
"	At North Limits of City,	"	6
*Cherry	East Line Summit St.	Eddy	8
"	West " Lafayette "	Lowry	8
* "	East " " "	Eddy	8
* "	West " College Ave.	"	8
*Clancy	North " Bridge St.	Flowers	6
*Clinton,	" " " "	Eddy	6
Coit Ave.	" " " "	Lowry	14
* "	" " Hastings "	Flowers	6
Division,	South " Bridge "	Lowry	12
"	" " Lyon "	"	12
"	" " Fulton "	"	12
* "	" " Cherry "	Eddy	12
* "	North " Wealthy Ave.	"	12
Eighth,	West " Scribner St.	Lowry	12
"	East " Front "	"	12
Erie,	On branch to Leitelt's Shop,	Ludlow	4
Fifth,	West Line Broadway St.	Lowry	6
*Fountain	East " Division "	Eddy	4
* "	" " Lafayette "	Flowers	6
* "	" " College Ave.	"	6
Front,	South " Bridge St.	Lowry	6
"	On branch to Brush Factory,	"	6
"	" " Powers' Mill,	"	4
"	" " Star Mills,	"	4
Fulton	East Line Division St.	"	10
"	West " Lafayette "	"	10
Ionia,	East " Monroe "	"	6
"	West " " "	"	6
Jefferson Ave.	South " Fulton "	"	6
"	North " Wealthy Ave.	"	6
Jefferson St.	South " Bridge St.	"	4
*Kent,	North " Lyon "	Eddy	6
* "	South " Bridge "	"	6
"	North " " "	Lowry	6
* "	South " Mason "	Eddy	6
Lafayette	North " Fulton "	Lowry	8

LIST OF STOP VALVES.

STREET.	LOCATION.	PATTERN.	SIZE. inches.
Lafayette	South Line Lyon St.	Lowry	8
*Lagrave,	" " Fulton "	Eddy	6
* "	" " Cherry "	"	6
*Leonard	East " Canal "	"	12
Livingston,	Foot of Reservoir Bank,	Lowry	20
Lyon,	West Line Ottawa St.	"	10
"	" " Division "	"	10
"	East " " "	"	10
"	West " Lafayette"	"	10
* "	East " " "	Eddy	14
Mason	Foot of Reservoir Bank,	Lowry	16
"	East Line Ionia St. on Waste,	"	12
"	" " Ottawa St.	"	16
"	West " " "	"	12
"	" " Canal "	"	12
Monroe	" " Division "	Ludlow	12
"	" " Ottawa "	"	10
Ottawa	North " Monroe "	"	12
"	South " Bridge "	"	12
"	North " " "	"	12
"	South " Newberry St.	"	12
"	North " Mason "	Lowry	16
"	South " Coldbrook "	"	16
"	On connec'n with C'mstock's pipes	Ludlow	4
Pearl	West Line Division St.	Lowry	6
"	" " Ottawa "	"	6
"	" " Canal "	"	6
"	East " Front "	"	6
*Prospect	North " Fulton "	Eddy	6
* "	South " Lyon "	Flowers	6
*Ransom,	North " Fulton "	Eddy	4
* "	South " Bridge "	Flowers	4
Scribner,	North " " "	Lowry	6
"	South " Eighth "	"	6
"	North " " "	"	8
"	South " Leonard "	"	8
"	North " " "	"	8
*Shawmut Ave	West " Front "	Ludlow	6
* "	East " Summer "	Flowers	6
* "	" " Jefferson "	Lowry	6
*Sheldon,	South " Fulton "	Eddy	6
Summer	" " Bridge "	Lowry	4
* "	North " Shawmut Ave.	Eddy	4
*Summit,	South " Cherry St.	"	8
Third,	West " Broadway "	Lowry	4
*Washington,	" " College Ave.	Eddy	4
* "	East " Lafayette St.	"	4
Waterloo	South " Monroe St.	Lowry	8
*Winter	North " Shawmut Ave.	Eddy	4
Engine House,	North End Supply Pipe,	Lowry	20
" "	South End Supply Pipe,	"	20
" "	On branch to Well,	"	20
*Settling Basin	On Carrier Creek Inlet	Eddy	20
* " "	On Coldbrook Creek Inlet,	"	20
* " "	On Outlet,	"	20

20-inch.	16-inch.	14-inch.	12-inch.	10-inch.	8-inch.	6-inch.	4-inch.	TOTAL.
7	4	3	25	10	12	33	17	111

Eddy, 28—Flowers, 10—Lowry, 62—Ludlow, 11.

LOCATION OF HYDRANTS.

Matthews Hydrants.

South West Corner of Bridge and Kent Streets.
“ “ “ “ “ Canal “
North “ “ Canal “ Erie “
“ “ “ “ “ Huron “
“ “ “ “ “ Lyon “
“ “ “ “ “ Pearl “
South East “ Monroe “ Waterloo “
“ “ “ “ “ Ottawa “
“ “ “ “ “ Ionia “
“ “ “ “ “ Spring “
North West “ Ottawa “ Bridge “
“ “ “ “ “ Hastings “
“ “ “ “ “ Trowbridge “
“ “ “ “ “ Fairbanks “
South “ “ “ “ Newberry “

Ludlow Hydrants.

North West Corner of Lyon and Ionia Streets.
“ “ “ “ “ Division “
“ East “ Ottawa “ Fountain “
“ West “ “ “ Pearl “
“ “ “ “ “ Lyon “
“ “ “ “ “ Bronson “
* “ “ “ Cherry “ Lagrave “
* West Side Kent Street, between Lyon and Bronson Streets.
* “ “ “ “ “ Bronson “ Bridge “
* “ “ “ “ “ Trowbridge and Fairbanks “
* “ “ “ “ “ Fairbanks “ Newberry “
* “ “ “ “ “ Newberry “ Mason “
* North “ Cherry “ opposite Paris Avenue.

Lowry Hydrants.

Intersection of Barclay St. with Bridge, Bronson and *John.
“ Bridge “ East “ Ionia, Division and Clinton.
“ “ “ “ “ Livingston, Coit & *Lafayette.
“ “ “ West “ Front, Scribner and Turner.

Intersection of	Bridge-st.	west	with	Broad'y, Seward and Jefferson.
“	Broadway	“	“	First, Second and Third.
“	“	“	“	Fourth, Fifth and Sixth.
“	“	“	“	Seventh and Eighth.
“	Bronson	“	“	*Prospect, *College and *Union
“	“	“		*Between Prospect “ College
“	Canal	“	“	Leonard and Quimby.
	“	“		Two bet. Leonard and Quimby·
	“	“		One North of Quimby St.
“	Cherry	“	“	*Summit, *Calder & *Almy.
“	“	“	“	*Ionia, Luce and Lafayette.
“	“	“	“	*Prospect, *Madison &*College.
“	Clinton	“	“	*Hastings,*Trowbridge &*Fairbanks.
“	Coit Ave.	“	“	*Trowbridge.
“	Division	St.	“	Bronson, Pearl and Fountain
“	“	“	“	Park, Fulton and Island.
“	“	“	“	Oakes, Cherry and *Maple.
“	“	“	“	*Goodrich and *Wealthy.
“	Eighth	“	“	Turner, Scribner and Front.
“	Fifth	“	“	Seward.
“	“	“		One bet. Seward and Broadway
“	Fountain	“	“	*Bostwick, *Ransom & *Barclay
“	“	“	“	Lafayette, *Prospect & *College
“	“	“	“	*Union and *Grand
“	“	“	“	*one bet. Prospect & College.
“	Front	“	“	Bowery,Valley,Allen,& Shawm't
“	Fulton	“	“	Sheldon, Ransom and Barclay
“	“	“	“	Lafayette and Prospect
“	Hastings	“	“	*Clancy, Coit & Livingston
“	Ionia	“	“	Pearl, Fountain and Louis
“	“	“	“	Fulton, Island and Oakes
“	Jefferson	Ave.	“	Island, Oakes and Cherry
“	“	“	“	Maple, Goodrich and Wealthy
“	Jefferson	Street	“	Bowery, Chatham and Jackson
“	“	“	“	Sibley and *Shawmut
“	Kent	“	“	*Bronson, Lyon and Hastings
“	“	“	“	Trowb'ge,*Fairbanks&*Newb'y
“	Lafayette	“	“	Washington, John and Bronson
“	Lagrave	“	“	*Island, *Oakes and *Maple
“	Livingston	“	“	Trowb'ge,Fairbanks &Newberry
“	Louis	“	“	Campau
“	Leonard	“	“	*Ionia, *Taylor and *Plainfield
“	Lyon	“	“	Bostwick, Ransom and Barclay
“	“	“	“	Lafayette,*Prospect and *College
“	“	“		*One bet. Prospect and College

Intersection of Mason street with Clinton, Ionia, Kent and Canal.
" Ottawa " " Mason, Walbridge and Coldbrook
" Pearl " " Campau and Arcade
" Ransom " " *Bronson and *Park
" Scribner " " First, Second, Third and Fourth
" " " " Fifth, Sixth, Tenth and Eleventh
" " " " Twelfth, Leonard and Crosby
" " " " Myrtle and Webster
" Shawmut Ave. " *Court, *Mt. Vernon & *W. Division
" Sheldon Street " *Island and *Oakes
" Summer " " Bowery, Allen and Shawmut
" " " " Grand Rapids and Indiana R. R.
" Summit " " *Williams and *Bartlett
" Third " " Alabama and Seward
" Washington " " *Prospect, *Madison & *College
" Waterloo " " Louis, Ferry and Fulton
" Winter " " Allen and Shawmut

One in center of Section 8, Campau Platt.

Total, Matthews Hydrants,	15
" Ludlow "	13
" Lowry "	171
Total Hydrants,	199

Location of Lowry Hydrant Bases.

Intersection of Bridge Street East with Bostwick and Ransom
" " " West " Alabama
" Canal " with Legrand and Force Main
" Division " " Lyon, Monroe and Cherry
" Front " " Branch to Powers' Mill
" Fulton " " E. Park Place and W. Park Place
" " " " Lagrave St. and Jefferson Avenue
" Lafayette " " State
" Lyon " " Kent Alley
" Mason " " Branch to Old Pump
" Pearl " " Ledyard Alley
" Scribner " " Ninth,
" Summer " " Valley — 19

LOCATION OF SAFETY VALVES.

On Lyon Street, 24 feet east of Dock.

On Allen Street, at Tail Race.

CONTENTS OF DISTRIBUTING RESERVOIR.

Depth of Water.	U. S. Gallons.	Increase.	Depth.	U. S. Gallons.	Increase.
1 foot.	229,158	....	14 feet.	3,885,023	328,594
2 “	465,330	236,172	15 “	4,222,007	336,984
3 “	708,623	243,293	16 “	4,567,486	345,479
4 “	959,142	250,519	16½ “	4,743,444	175,958
5 “	1,216,992	257,850	17 “	4,921,566	178,122
6 “	1,482,280	265,288	17½ “	5,101,864	180,298
7 “	1,755,112	272,832	18 “	5,284,352	182,488
8 “	2,035,592	280,480	18½ “	5,469,043	184,691
9 “	2,323,827	288,235	19 “	5,655,950	186,907
10 “	2,619,922	296,095	19½ “	5,845,087	189,137
11 “	2,923,984	304,062	20 “	6,036,466	191,379
12 “	3,236,117	312,133	20½ “	6,230,102	193,636
13 “	3,556,429	320,312	21 “	6,426,006	195,904

STATEMENT OF EXPENDITURES,

May 1, 1875 to May 1, 1876.

Construction of Water Works.

1875.		1. REAL ESTATE.	
July 13.	Order No. 616.	P. R. L. Peirce. Site for Settling Basin..............................	$ 15,000 00
1876 Jan. 11.	“ “ 2634.	City Marshal. Taxes for grading Clinton street......................	312 50
			$ 15,312 50
1875.		2. PIPE SYSTEM.	
May 11.	Order No. 48.	R. J. Mitchel. Repairs............$	7 50
June 15.	“ “ 287	W. H. Powers. Hydrant Boxes...	8 75
“ 29.	“ “ 399	Boston Machine Co. Hydrant....	70 00
July 13.	“ “ 591	Farrington & Branch. Laying Pipe......................	1,000 00

Aug. 10,	Order No.	849	W. H. Powers, hydrant boxes...	15	80
Sept. 7,	" "	1154	N. T. Smith, setting hydrants...	31	50
" "	" "	1155	A. Leitelt Bros, & Co., altering hydrants..........................	2,079	00
" 14,	" "	1263	Farrington & Branch, laying pipe..............................	474	27
Oct. 12,	" "	1506	A. Leitelt Bros. & Co., altering hydrants,.........................	1,111	00
" "	" "	1507(Pt.)	A. Leitelt Bros. & Co., altering hydrants..........................	70	57
" 12,	" "	1511	N. T. Smith, altering hydrants...	13	12
" 19,	" "	1539	Smith & McEwan, laying pipe......	1,289	77
' 26.	" "	1673	T. C. Brooks. " "	4,000	00
Nov. 2.	" "	1751	" " "	1,598	83
" 2.	" "	1752	Smith & McEwan " "	2,664	89
" 9,	" "	1897(Pt.)	W. H. Powers, hydrant boxes...	21	90
" 16,	" "	1959	T. C. Brooks, Repair of Streets	6	00
" 23,	" "	2096	Smith & McEwan, laying pipe. .	1,954	05
" "	" "	2097	Farrington & Branch, " " ...	4,057	20
" "	" "	2099(Pt.)	Powers & Walker, hydrant...... boxes................................	9	00
" 30,	" "	2154	Farrington & Branch, laying pipe	1,620	36
" "	" "	2155	P. Grady, covering pipe	10	00
Dec. 7,	" "	2254	J. M. Gorham, cleaning streets...	3	00
" "	" "	2255	T. C. Brooks, laying pipe.........	8,465	51
" 14,	" "	2359	Farrington & Branch, laying pipe	2,500	00
" 21,	" "	2410(Pt,)	W. T. Powers & Son, lumber...	11	18
" "	" "	2414	M. Delong, hydrant boxes.........	5	57
" "	" "	2415	Farrington & Branch, lowering pipe	400	00
" "	" "	2416	T. C. Brooks, laying pipe.........	4,403	38
" "	" "	2417	Farrington&Branch laying pipe...	1,328	82
1876.					
Jan. 18,	" "	2743	Smith & McEwan, " " ...	608	36
" "	" "	2744(Pt.)	A. Leitelt Bros. & Co., hydrants pipe, &c...........................	125	00
" 25,	" "	2798	M Delong, lowering pipe.........	24	61
Feb. 15,	" "	3157	Board Pub. Works, arbitration...	391	30
" 22,	" "	3198	Farrington & Branch, laying pipe	1,526	00
" "	" "	3200	M. Delong, labor on trenches	6	50
Mar. 1,	" "	3269	E. P. Allis & Co., iron pipe.........	375	56
" 7.	" "	3395	N. T. Smith, repairs.................	16	10
Apr. 11.	" "	3820	Smith & McEwan, laying pipe....	72	89

April 26,	Order No.	4019	T. C. Brooks, hydrant..............	80 50
“ “	“ “	4020	N. T. Smith, repairs..................	24 75
			Bonds paid to Farrington & Branch, laying pipe...	10,000 00
				$ 52,592 54

1875. 3. PIPE UNDER GRAND RIVER.

Jun. 22,	Order No.	358	H. M. Reynolds. pitch....... ...	$ 4 50
July 13,	“ “	607	S. M. Pelton, labor......	15 00
“ “	“ “	608	F. Renshaw, “	1 00
“ “	“ “	609	W. H. Pelton, “	6 00
“ “	“ “	610	A. Schotey, “	7 50
“ “	“ “	611	C Hilton, “	7 50
“ “	“ “	612	J. Bennaway, “	7 50
“ 30,	“ “	647	William Bell, coating pipe.........	20 00
“ “	“ “	649	C. E. Belknap, blacksmithing...	12 30
“ “	“ “	651	S. M. Pelton, labor.................	134 12
“ 27,	“ “	707	“ “	216 87
“ “	“ “	708	D. Hastings, blacksmithing......	15 20
Aug. 3,	“ “	762	S. M. Pelton, labor	163 00
“ 10,	“ “	844	C. C. Comstock, pails..............	2 20
“ “	“ “	846	W. T. Powers & Son, lumber...	77 80
“ “	“ “	847	D. Hastings, blacksmithing......	14 84
“ “	“ “	848	Cleveland & Granger, teaming...	7 50
“ “	“ “	850	S. M. Pelton, labor......	127 90
“ 17,	“ “	961	“ “	129 65
“ 24,	“ “	1015	“ “	139 12
“ 31,	“ “	1080	“ “	151 74
“ “	“ “	1081	D. Hastings, blacksmithing......	10 25
Sept. 21,	“ “	1296	S. M. Pelton, labor	161 50
“ 28,	“ “	1337	“ “	101 50
Oct. 12,	“ “	1505	“ “	120 00
“ “	“ “	1507	(Pt) A. Leitelt Bros. & Co., labor and pipe........................	337 68
“ “	“ “	“ “	A. Leitelt Bros. & Co., tools...	2 70
“ “	“ “	1512	W. T. Powers & Son, lumber......	23 84
“ “	“ “	1513	S. M. Pelton, labor.................	117 75
“ 19,	“ “	1540	“ “	91 25
“ 26,	“ “	1671	“ “	119 25
“ “	“ “	1672	J. M. Gorham “	44 00
Nov. 2,	“ “	1750	Thos. Smith & Co., materials......	33 21
“ 9,	“ “	1898	S. M. Pelton, labor	31 37
“ 9,	“ “	1899	C. E. Belknap, blacksmithing......	35 45
“ “	“ “	1900	(Pt.)Foster, Stevens & Co., materials	97 80
“ 16,	“ “	1962	W. T. Powers, use of scow	12 00
Dec. 21,	“ “	2407	Jones & Merath, covering pipe ...	3 00
“ “	“ “	2412	(pt.) J. L. Shaw & Co., teaming....	10 00
“ “	“ “	2413	Widdicomb Furn're Co., basswood	3 30
				$2,616 59

4. CONNECTIONS WITH PUMPS.

(No expenditures during the year.)

5. RESERVOIR.

1875.					
May 11,	Order No.	48	Brooks & Sekell, construction,	$3,233	38
July 27,	“ “	714	R. Hilton & Son, side walk,	7	85
Nov. 16,	“ “	1960	Chas. H. Peale & Co., work on fence	23	15
				$3,264	38

6. SETTLING BASIN AND SUPPLY PIPES.

1875.					
June 8,	Order No.	233	N. T. Smith, clearing creeks,	$ 217	00
“ 15,	“ “	292	Powers & Walker, temporary pipe,	211	93
“ 22,	“ “	357	N. T. Smith, clearing creeks	61	87
Aug. 31,	“ “	1082	Peter Granger, settling basin,	595	00
Sept. 14,	“ “	1222	“ “ “ “	1020	00
“ 28,	“ “	1335	“ “ “ “	935	00
Oct. 12,	“ “	1514	“ “ “ “	1062	50
“ 26,	“ “	1674	“ “ “ “	300	00
“ “	“ “	1675	“ “ “ “	1200	00
Nov. 9,	“ “	1895	“ “ “ “	800	00
“ “	“ “	1897(Pt.)	Wm. H. Powers, boxes,	12	50
“ 23,	“ “	2098	Peter Granger, settling basin,	630	00
“ “	“ “	2099(Pt.)	Wm. H. Powers, bulk heads,	43	37
“ 30,	“ “	2152	P. W. King, laying pipe,	114	65
Dec. 14,	“ “	2361	Peter Granger, settling basin,	567	00
“ “	“ “	2362	Powers & Walker, box,	7	00
“ 21,	“ “	2404	T. C. Brooks, iron pipe	70	00
“ “	“ “	2405	Smith & Bell, laying pipe,	453	95
“ “	“ “	2406	Powers & Walker, stave pipe,	1000	00
“ “	“ “	2408	Z. G. Winsor, cement,	18	10
“ “	“ “	2409	Powers & Walker, bulkheads,	29	42
“ “	“ “	2410(Pt.)	Wm. T. Powers & Son, lumber	7	25
1876.					
Jan. 4,	“ “	2477	Powers & Walker, stave pipe,	1025	00
“ “	“ “	2478	Peter Granger, settling basin,	178	18
“ “	“ “	2479	Carpenter & Judd, wire	62	64
“ “	“ “	2480	H. Leonard & Son, sewer pipe,	51	00
“ 25,	“ “	2798	Smith & Bell, laying pipe,	262	93
Feb. 1,	“ “	2883	“ “ “ “	300	00
“ “	“ “	2884	Powers & Walker, stave pipe,	275	00
“ 8,	“ “	3021	Smith & Bell, laying pipe,	150	00
“ 15,	“ “	3158	“ “ “ “	67	68
“ “	“ “	3159	G. R. Wire Works, screen,	65	27
“ “	“ “	3160	Smith & Bell, laying pipe,	99	35
Mar. 1,	“ “	3270	Board Pub. Works, laborers on pipe,	112	53
“ 14,	“ “	3453	Utes & Livingston, filling,	15	76

Apr. 26,	Order No. 4021	Board Pub. Works, laborers on pipe...	52	97
“ “	“ “ 4022	Peter Granger, settling basin,......	213	50
“ “	“ “ 4023	“ “ “ “	200	00
“ “	“ “ 4024	“ “ “ “	82	88
			$12,571	23

7. ENGINE HOUSE, TEMPORARY.

1875,				
Aug. 3,	Order No. 761	M. V. Aldrich, moving house,.........$	20	00
			$ 20	00

1875. 8. ENGINE HOUSE, PERMANENT.

May 18,	Order No. 102	R. Hilton & Son, construction,......$	1,786	25
June 1,	“ “ 151	Edward Racine, screens,...............	20	00
“ “	“ “ 152	Kingsbury & Bennet, fire brick.........	143	40
“ 15,	“ “ 288	Schmidt & Hirth, stone cutting.........	24	15
“ “	“ “ 289	Widdicomb Furniture Co., lumber...	2	10
“ “	“ “ 290	Brown & Clark, brick,.................	238	80
“ “	“ “ 291	C. C. Comstock, lumber,........... ...	1	76
“ 29,	“ “ 400	J. T. Elliott, lightning rod	20	00
“ “	“ “ 401	W. T. Powers & Son, lumber,.........	1	44
July 13	“ “ 592	L. M. Page, painting,...........	2	93
“ 27,	“ “ 706	R. Davidson, setting boiler, ...	241	15
Aug. 3,	“ “ 763	Davidson Bros., cement.................	2	25
Sept. 7,	“ “ 1153	Chas. H. Peale & Co., floor......	423	96
Oct. 12,	“ “ 1510	“ “ “ carpentering......	289	59
Dec. 14,	“ “ 2360	Carpenter & Knowlan, painting.........	312	88
1876.				
Mar. 21,	“ “ 3588	C. H. Peale & Co., carpentering......	38	70
			$3,548	36

1875. 9. PUMPING MACHINERY—PERMANENT.

June 1,	Order No. 153	Butterworth & Lowe, construction...$	3,000	00
“ 22,	“ “ 368	“ “ “ ...	1,500	00
July 20,	“ “ 650	A. Leitelt Bros. & Co., tools, materials, etc.	126	76
Sept. 14,	“ “ 1262	W. M. Ferry, arbitration.................	75	00
“ “	“ “ 1265	Butterworth & Lowe, construction...	2,408	98
Oct. 12,	“ “ 1509	“ “ “ ...	13	32
Dec. 21,	“ “ 2412(Pt.)	J. L. Shaw & Co., teaming............	5	00
1876.				
Jan. 18,	“ “ 1744(Pt.)	A. Leitelt Bros. & Co., pipe,............	50	00
Feb. 12,	“ “ 3199	Butterworth & Lowe, extra piston	105	50
			$7,284	56

10. PUMPING MACHINERY—TEMPORARY.

No expenditures during the year.

11. METERS.

1875.			
May 11,	Order No. 47	E. W. Muenscher, freight	$ 8 18
June 8,	“ “ 234	Thomas Smith & Co., setting	58 97
July 13,	“ “ 590	Schriver, Weatherly & Co., setting	31 65
“ 27,	“ “ 703	Thos. Smith & Co., setting	40 77
“ “	“ “ 705	R. Worthington, meters	178 00
Aug. 10,	“ “ 845	Thos. Smith & Co., setting	13 43
Sept. 28,	“ “ 1336	Union Water Meter Co., meters,	414 90
Nov. 23,	“ “ 2151	Thos. Smith & Co., setting	79 72
			$ 825 62

12. HOSE HEADS.

No expenditure during the year.

13. ENGINEERING AND SUPERINTENDENCE

1875.			
July 30,	Order No. 648	Demetrius Turner, engines	$ 875 00
Nov. 23,	“ “ 2100	G. R. Ray, pipe	63 65
1876.			
Jan. 18,	“ “ 2759	P. Hogan, general	2,500 00
			$3,438 65

14. PRINTING AND ADVERTISING.

1875.			
May 18,	Order No. 105	M. H. Clark & Co., advertising	$ 4 90
Aug. 17,	“ “ 962	Milwaukee News, “	9 00
“ “	“ “ 963	Detroit Post, “	3 75
Oct. 12,	“ “ 1508	Chicago Tribune, “	22 40
			$ 40 05

15. EXPENSES OF LOAN.

1875.			
June 29,	Order No. 479	L. H. Randall, express,	$ 1 75
July 13,	“ “ 613	P. R. L. Peirce, engraving	79 00
“ “	“ “ 615	L. H. Randall, transportation	24 80
Aug. 10,	“ “ 903	P. R. L. Peirce, telegraphing,	24 95
“ 31,	“ “ 1077	L. H. Randall, express	59 19
			$ 189 69

16. MISCELLANEOUS.

1875.			
May 18,	Order No. 101	T. D. Gilbert, telegraphing	$ 38 66
Nov. 9,	“ “ 1896	F. W. Greene & Co., vise	10 45
“ “	“ “ 1900	Foster, Stevens & Co., tools,	60 48
“ 30,	“ “ 2153	“ “ “ iron	92
Dec. 7,	“ “ 2253	A. B. Farnsworth, traveling expenses	14 30
“ 21,	“ “ 2411	Shriver, Weatherly & Co., setting stop	
1876.		cocks	42 79
Jan. 11,	“ “ 2617	Foster, Stevens & Co., supplies	72 20
Mar. 7,	“ “ 3396	Blair, Stone & Kingsley, legal services,	50 00
			$ 289 80

Total amount paid on construction..........................	$101,993 97
Paid previous to May 1, 1875..................................	248,772 47
Total paid for construction....................................	$350,766 44

Maintenance and Operation of Water Works.

1875.							
May	11,	Order	No.	49	M. S. Youngs, labor at pumping works	$ 71	72
“	“	“	“	50	D. C. Sawyer “ “ “ “	52	50
“	“	“	“	51	H. Ritter, team work at “ “	18	38
“	“	“	“	52	“ “ “ “ “ “	11	38
“	25,	“	“	132	M. S. Youngs, labor “ “ “	28	00
June	1,	“	“	154	A. Leitelt Bros. & Co, supplies, pumping works....................................	142	01
“	“	“	“	155	H. Ritter, team work, pumping works	24	51
“	“	“	“	156	D. C. Sawyer, labor “ “	32	50
“	“	“	“	157	A. Leitelt Bros. & Co, supplies, pumping works....................................	99	55
“	8,	“	“	235	W. Morman, wood..........................	106	50
“	“	“	“	236	S. S. Bailey “	183	00
“	“	“	“	237	M. S. Youngs, labor at pumping works	42	00
“	15,	“	“	293	Thos. Smith & Co, tapping,...............	75	30
“	“	“	“	294	Schriver, Weatherly & Co, tapping......	131	36
“	22,	“	“	359	C. C. Comstock, wood.......................	290	63
“	“	“	“	360	D. C. Sawyer, labor at pumping works,	28	25
“	“	“	“	361	M. S. Youngs, “ “ “ “	29	00
“	“	“	“	362	Tarbox & Pierce, printing..................	1	40
“	“	“	“	363	J. L. Shaw, labor at engine house.........	5	00
“	29,	“	“	402	H. Ritter, team work “ “	6	13
July	18,	“	“	593	J. Baisch, labor “ “	5	25
“	“	“	“	594	O. N. Brown, team “ “ “	25	45
“	“	“	“	595	M. H. Clark & Co, printing pamphlets,	19	50
“	“	“	“	596	Hulbert Bros., wood,.........................	106	62
“	“	“	“	597	Schriver, Weatherly & Co, tapping......	52	82
“	“	“	“	598	C. C. Comstock, oil..........................		65
“	“	“	“	599	Thos. Smith & Co, tapping..................	71	25
“	“	“	“	600	E. W. Muenscher, freight on meters....	5	65
“	20,	“	“	652	H. Christensen, fireman,.....................	84	00
“	“	“	“	653	A. Leitelt Bros. & Co, supplies,.........	46	36
“	“	“	“	654	N. T. Smith, labor..............................	5	25
“	“	“	“	655	M. V. Bentley, oil...............................	10	65
“	“	“	“	656	Demetrius Turner, engineer...............	125	00
Aug.	3,	“	“	764	Schriver, Weatherly & Co, tapping......	32	16
“	“	“	“	765	P. Eagan, special policeman,...............	48	00
“	10,	“	“	851	A. B. Turner & Co, printing,................	8	50
“	“	“	“	852	Nelson, Matter & Co, pumping............	80	00
“	“	“	“	853	Thos. Smith & Co, tapping,................	39	75

Aug. 24,	Order No. 1016	Dygert Bros. & Co, printing notices	4 50
Sept. 7,	" " 1156	N. T. Smith, repairs on engine house	8 87
" 14,	" " 1223	M. V. Aldrich, rent of ground,	50 00
" 21,	" " 1297	H. Christiansen, fireman	93 00
"	" " 1298	M. V. Bentley, oil	13 20
" 28,	" " 1338	Thos. Smith & Co, tapping	40 00
Oct. 12,	" " 1515	A. Leitelt, Bros. & Co, repairs, engine	27 00
" "	" " 1516	Butterworth & Lowe, " "	6 00
" "	" " 1517	" " assis't engineer	389 60
" "	" " 1518	G. R. Ray, " "	45 00
" 19,	" " 1541	D. Turner, engineer	375 00
" "	" " 1542	Boston Belting Co, engine valves	119 70
" 26,	" " 1676	G. R. Ray, assis't engineer	30 00
" "	" " 1677	G. Kirk, labor, engine house	7 00
" "	" " 1678	Schriver, Weatherly & Co, supplies	3 50
" "	" " 1679	" " " tapping	22 16
Nov. 2,	" " 1753	Farrington & Branch, repairs, pipe	6 00
" "	" " 1754	E. H. Ashcroft, Scotch tubes,	14 00
" "	" " 1755	Thos. Smith & Co, tapping	41 75
" "	" " 1756	" " " setting meters	70 77
" 9,	" " 1901	Foster, Stevens & Co. hardware,	4 33
" "	" " 1902	H. Christiansen, fireman	91 50
" 16,	" " 1961	Schriver, Weatherly & Co, supplies	18 52
" 23,	" " 2049	C. W. Warrell, descriptive list,	25 00
" 30,	" " 2156	Thos. Smith & Co, tapping	16 75
" "	" " 2157	W. H. Fuller, assis't engineer,	100 00
Dec. 7,	" " 2256	A. B. Farnsworth, stationery	26 15
" "	" " 2257	Schriver, Weatherly & Co. tapping,	34 14
" "	" " 2258	P. Christiansen, labor, engine house,	2 25
1876.			
Jan. 4,	" " 2481	C. C. Comstock, wood	228 00
" "	" " 2482	Michigan Barrel Co, wood	1,202 73
" 11,	" " 2619	Foster, Stevens & Co, supplies	11 56
" "	" " 2620	Schriver, Weatherly & Co, tapping etc.,	47 99
" "	" " 2621	" " " labor, engine house,	53 38
" "	" " 2622	J. VanderLaan, repairs, pipe,	20 75
" "	" " 2635	A. B. Farnsworth, clerk,	438 81
" 18,	" " 2745	W. H. Fuller, assis't engineer,	90 00
" "	" " 2746	H. Christiansen, fireman,	91 50
" "	" " 2747	Butterworth & Lowe, supplies,	6 25
" "	" " 2748	McDermot Bros. setting meter	3 00
" "	" " 2749	G. R. Gas Light Co., coke,	18 42
Feb. 1,	" " 2885	McDermot Bros. repairs, pipe,	2 50
" "	" " 2886	Thos. Smith & Co, tapping, etc.,	41 45
" 8,	" " 3020	C. C. Comstock, wood	278 26

Feb. 8,	Order No. 3022	H. Christiansen, fireman	46 50
" "	" " 3023	W. H. Fuller, assis't engineer	77 50
" "	" " 3024	Kingsbury & Bennett, coal	10 80
" "	" " 3026	A. B. Farnsworth, clerk,	62 50
" "	" " 3027	Dygert Bros. & Co, binding books	10 00
" "	" " 3029	N. T. Smith, repairs, logs	3 69
" "	" " 3030	" " Wyckoff	7 50
" 22,	" " 3201	Schriver, Weatherly & Co, tapping, etc,	19 50
Mar. 1,	" " 3271	James Blair, blankets,	5 50
" 7,	" " 3297	N. T. Smith, repairs, pipe,	8 12
" "	" " 3298	O. B. Gibson, straw	2 50
" "	" " 3299	W. H. Fuller, assis't engineer	72 50
" 14,	" " 3449	A. B. Farnsworth, cartage	13 36
" "	" " 3452	" clerk,	62 50
" "	" " 3454	H. Christiansen, fireman	43 50
" "	" " 3455	A. B. Farnsworth, freight,	40 73
" "	" " 3456	C. C. Comstock, wood	306 00
" 21,	" " 3587	C. H. Peale & Co, repairs, engine house	67 30
" "	" " 3589	Collector 5th ward, taxes	74 13
" "	" " 3593	A. B. Turner & Co, printing	1 20
Apr. 11,	" " 3814	A. B. Farnsworth, clerk,	62 50
" "	" " 3815	Schriver, Weatherly & Co, tapping,	5 16
" "	" " 3816	C. C. Comstock, wood	180 00
" "	" " 3817	W. H. Fuller, assis't engineer,	77 50
" "	" " 3818	H. Christiansen, fireman	46 50
" "	" " 3819	Hatch & Hayden, hydrant boxes,	1 35
" 18,	" " 3918	Sproule & McGurrin, setting meter	3 67
" "	" " 3919	Thos. Smith & Co, tapping	18 25
" 26,	" " 4016	N. T. Smith, repairs, pipe,	21 26
" "	" " 4017	C. C. Comstock, wood	61 50
" "	" " 4018	C. H. Southwick, oil	21 23

Total expended for maintenance and operation,	$7,793 52
" " previous to May 1, 1875,	6,132 31
" " since opening of Works,	$13,925 83

CORRECTIONS.

On the first page, the word "miles" is omitted after "— 4.96" in the line giving the total length of completed street improvements for the year ending May 1, 1876.

In the table on page 6 showing the length and sizes of sewers constructed since May 1st, 1875, the line relating to the Jefferson Avenue sewer, should read "n. line lot 5, block 1, Smith's Addition," instead of "n. line block 1, Smith's Addition."

REPORT

OF THE

CITY ENGINEER

GRAND RAPIDS, MICHIGAN.

MAY 1st, 1877.

REPORT

—OF THE—

CITY ENGINEER.

MAY, FIRST, 1877.

OFFICE OF THE BOARD OF PUBLIC WORKS,
Grand Rapids, Mich., May 1st, 1877.

To the Honorable, the Board of Public Works of the City of Grand Rapids:

I herewith submit a report of the Public Works carried on under the direction of the Board since May 1st, 1876.

STREET IMPROVEMENTS.

The following street improvements have been completed :

Grading and Paving with Wood and Stone	**12631**	**Lineal Feet**
Grading, Graveling and Paving Gutters	**18928**	**" "**
Grading and Graveling	**1274**	**" "**
Total	**32833**	**" "**
	6.14 miles.	

The following improvements are in progress:

Grading, Graveling and Paving Gutters,	**2905**	**Lineal Feet**
Grading and Graveling	**2565**	**" "**
Grading	**1356**	**" "**
Total	**6826**	**Lineal Feet,=1.29 miles.**

The greater part of the work completed was commenced during the previous year, but very few improvements having been commenced dur-the past year.

The total length of streets now opened in the city, is 131.62 miles, of which are:

Graded and Paved with Wood	0.15	miles
Graded and Paved with Wood and Stone	2.92	"
Graded and Paved with Stone	1.55	"
Graded and Graveled and Gutters Paved	21.91	"
Graded and Graveled	29.26	"
Graded	8.02	"
Unimproved	67.81	"

RESERVOIRS.

One brick reservoir of 500 barrels capacity has been constructed for the use of the Fire Department at the intersection of Wealthy Avenue and Henry Street. It has to be filled from the nearest hydrant.

SEWERS.

The total length of sewers constructed was 7362 feet, but little more than one-half as much as during the previous year, but the proportion of main sewers was much greater, bringing the cost up to $20,005.11 or an average of $2.71¾ per foot. In connection with these sewers 23 manholes and 28 catch basins were constructed

In addition to the above, 760 feet of sewers, 3 man-holes, and 54 basins were constructed in connection with the street improvements. The old wooden sewer in Wenham Avenue was taken up for 347 feet.

The following table shows the lengths and sizes of the sewers constructed:

LENGTH AND SIZES OF SEWERS CONSTRUCTED SINCE MAY 1st, 1876.

STREET.	FROM	TO	LENGTH IN FEET AND SIZE IN INCHES.										Man Holes	Catch Basins
			BRICK						PIPE.			Total.		
			72	36x54	30x45	18x27	16x24	18	18	15	12			
Coldbrook..	200'e of Tay. st.	Grand River...	......	......	......	......	......	......	273	279	570	1122	4	9
Fountain ...	200'e of Col. ave	cen. Ransom st	......	......	......	......	......	1234	......	......	1154	2388	7	11
Wenham ...	w line Lafa'e st	w line Div. st...	......	16	343	947	300	......	......	......	......	1606	6	8
Winter &c..	s line Bridge st	Powers tail race	2246	......	......	......	......	......	......	......	......	2246	6	......
Bridge......	Center Canal st	Kent Alley.....	......	......	......	......	......	......	168	.....	......	168	1	6
Leonard....	e line Canal st.	Grand River...	......	......	......	......	......	......	206	......	......	206	......	3
Mason	e line Canal st.	Grand River...	......	......	......	......	......	......	......	128	......	128	......	3
Walbridge..	e line Canal st.	Grand River...	......	......	......	......	......	......	......	94	......	94	......	3
518' n. Leo'd	e line Canal st.	Grand River...	......	......	......	......	......	......	140	......	......	140	......	......
Cedar	w line Clancy...	Coldbrook.....	......	......	......	......	......	......	24	......	......	24	1	3
Other Sts.:			......	......	......	......	......	......	......	......	......	....	1	36
TOTAL..................			2246	16	343	947	300	1234	811	501	1724	8122	26	82

The total length of sewers now in use in the city, is as follows:

Brick Sewers	37.311 lineal feet	=7 miles	351 feet
Clay Pipe Sewers	34.178 "	" =6 "	2498 "
Cement Pipe Sewers	2.680 "	" =0 "	2680 "
Wooden Sewers	8.274 "	" =1 "	2994 "
Total	82.443 lineal feet	=15 miles	3243 ft.

The following are the sizes as near as can be ascertained, and the lengths in feet of each size:

BRICK SEWERS.

10'-4"x6'-2", 358; 10'x6', 106; 6', 2246; 5'x6', 1164; 4'x5', 2889; 40"x60", 712; 36"x54", 36; 3'x4' 5117; 30"x45", 343; 2'x3', 3327; 22"x33", 572; 24"x30", 1544; 20"x30", 3614; 20"x24", 3551; 18"x27", 947; 18"x24", 6411; 16"x24", 3142; 18", 1234.

CLAY PIPE SEWERS.

24", 358; 22", 367; 20", 1173; 18", 6780; 15", 6850; 12", 16514; 9", 2310.

CEMENT PIPE SEWERS.

18", 96; 12", 1701; 9", 513; 8", 370.

WOODEN SEWERS.

3'x4', 3981; 18"x24", 1635; 18"x18", 850; 12"x18", 834; 12"x12", 974.

The old culvert under Canal Street near Hastings having fallen in, was cleaned out and repaired. It was built about 30 years ago and covered with timbers, part white oak and part white pine. On uncovering it the oak timbers were all found badly decayed and many of them broken, while the pine timbers were found perfectly sound, except about half an inch in depth all around.

A portion of the pipe sewer on Monroe Street failed and has been replaced by brick. This failure makes it advisable not to use any more pipe for sewers, of a great diameter than 18 in.

SUMMARY OF WORK DONE.

In the accompanying table will be found a list of all the improvements completed by the Board since May 1st, 1876, with the name of the contractor, and the cost for construction and for engineering, assessment and printing. Those marked * were in progress May 1st, 1876. From this table we deduce the following summary.

Total cost of improvements completed by the Board:

Grading and Paving	$76,972 15
Grading, Graveling and Paving Gutters	44,453 07
Grading and Graveling	2,610 08
Sewers	20,005 11
Reservoirs	230 00
Total cost of completed work	$144,270 41
Add payments made on work in progress	6,779 10
Add payments made on Water Works construction	36,185 00
Add payments made on Water Works operation	12,663 23
Total expenditure	$199,897 74
Deduct estimates paid previous to May 1st, 1876	43,413 75
Total expenditures during the year	$156,483 99

IMPROVEMENTS COMPLETED MAY 1st, 1876 TO MAY 1st, 1877.

GRADING AND PAVING WITH WOOD AND STONE.

STREET.	FROM	TO	LENGTH FEET.	CONTRACTOR.	COST.			
					CONSTRUCT'N.	ENGINEERING ASSESSMENT & PRINTING.	TOTAL.	PER FOOT
Bridge............	Powers' Canal...	Broadway St..	1044	T. C. Brooks......	$ 4,932 35	$ 259 60	$ 5,191 95	$4 97
Canal............	Pearl Street.....	North Limits.	9273	Leonard & Sterling	60,228 18	1,503 54	61,731 72	6 65
Division..........	Monroe Street...	Lyon St......	1279	John Collins......	4,574 55	237 88	4,812 43	3 76
Lyon.............	Canal Street.....	Division St...	1035	John Collins......	4,992 45	243 60	5,236 05	5 06
....	....	....	12631	....	$74,727 53	$2,244 62	$76,972 15	.....
GRADING, GRAVELING AND PAVING GUTTERS.								
Bartlett...........	Division St......	Waterloo St..	2569	Utes & Livingston	$ 7,339 57	$ 206 77	$ 7,546 34	$2 94
Cedar............	Clancy St........	College Ave..	1650	Utes & Livingston	4,810 65	171 00	4,981 65	3 02
Cemetery........	Fountain St......	Fulton St.....	756	Joel Collins.......	1,144 01	94 86	1,238 87	1 64
Clinton...........	176's of Trowb'ge	Mason St.....	1876	Patrick Grady....	5,295 24	230 10	5,525 34	2 95
Coldbrook........	Canal St....	Coit Ave......	1572	Leonard& Sterling	2,866 07	219 60	3,085 67	1 96
Goodrich.........	Division St	Waterloo St..	2878	Alfred B. Turner..	7,867 00	208 25	8,075 25	2 81
Holland..........	Lafayette St.....	Prospect St...	328	Utes & Livingston	379 00	84 46	463 46	1 41
Ionia.............	Cherry St........	Evergreen St.	4578	Patrick J. Britton.	10,093 75	437 64	10,531 39	2 30
*Michigan........	Bridge St........	Fourth St.....	1510	K. S. Pettibone...	999 20	115 54	1,114 74	
Ransom..........	Fountain St......	Lyon St......	711	John Collins......	1,546 60	93 00	1,639 60	2 31
Al'y bt. Ot'a & Ionia	Hastings St......	Trowbridge St	500	Utes & Livingston	175 00	75 76	250 76	0 50
....	....	....	18928	....	$42,516 09	$ 1,936 98	$44,453 07	.....

*Partly done by private enterprise.

IMPROVEMENTS NOW IN PROGRESS.

STREET.	FROM	TO	LENGTH FEET.	CONTRACTOR.	IMPROVEMENT.	ESTIMATED COST.
Bridge	Broadway	Gold	1400	P. J. Britton	Gra. Grav.Pav.Gut	$5000
Front	Bridge	Pearl	1356	Pow's & Converse	Grading	2500
Lafayette	Wealthy	Withey	2565	T. McGee	Grad'g & Grav'ng.	2600
Wenham	Division	Lafayette	1505	Utes & Livingst'n	Gra. Grav.Pav.Gut	2800
			6826			$12,900

On these improvements estimates have been paid to the amount of $6,779.10 The first two are practically completed, but not yet accepted.

GRADING AND GRAVELING.

STREET.	FROM	TO	LENGTH FEET.	CONTRACTOR.	COST.			
					CONSTRUCT'N.	ENGINEERING ASSESSMENT & PRINTING.	TOTAL.	PER FOOT.
Bridge...........	Canal St.........	Canal Bridge.	75	Property Owners..	$	$	$	$
Indiana	Bridge St........	Jackson St....	924	John Collins......	2,107 00	117 00	2,224 00	2 41
Al. bt. Div. & Spring	Cherry St........	Williams	275	Wm. H. Brooks..	310 00	76 08	386 08	1 40
....	....	....	1274	....	$ 2,417 00	$ 193 08	$2,610 08	......

SEWERS.

Coldbrook St.....	200' e of Taylor..	Grand River..	1122	Joel Collins.......	$ 2,736 00	$ 167 32	$ 2,903 32	$2 59
Fountain St.......	200' e of College.	cen. Ransom..	2388	Joel Collins.......	2,616 80	271 92	2,888 72	1 21
Wenham Ave.....	w line Lafayette..	w line Division	1606	Utes & Livingston	3,523 27	593 00	4,116 27	2 57
Winter and Others	s line Bridge.....	Pow'rs T. Race	2246	T. C. Brooks......	8,783 60	1,313 20	10,096 80	4 50
....	....	....	7362	....	$17,659 67	$ 2,345 44	$20,005 11	......

RESERVOIRS.

Wealthy Avenue and Henry Street..........................	Ralph Weartman.	$ 230 00

WATER WORKS.

On the 5th day of June the Common Council made an appropriation of $12,000 in bonds for necessary improvements and extensions, and on the 14th of August a further appropriation of $20,000 for extensions. Under these appropriations contracts were made with Dennis Long & Sons for pipe; R. D. Wood & Co. for valves; Boston Machine Co. for hydrants; T. C. Brooks for laying pipe, and W. R. Coates for furnishing and laying pipe. These contracts were all promptly performed, and the following work done under them:

3955.18	Lineal	Feet	12	inch	Cast	Iron	Pipe.
1597.93	"	"	10	"	"	"	"
6435.57	"	"	8	"	"	"	"
3914.85	"	"	6	"	"	"	"
1863.10	"	"	4	"	"	"	"

4	12	inch	Stop	Valves.
3	10	"	"	"
8	8	"	"	"
5	6	"	"	"
2	4	"	"	"

33	Lowry	Hydrants.
3	Ludlow	"

Or a total of 17766.63 feet (3.37 miles) of pipe, 22 stop valves and 36 hydrants; 22 feet of Wyckoff pipe were replaced by the new iron pipe laid.

The streets upon which these pipes were laid and the location of the valves and hydrants, are shown in the appendix.

The total length of pipe now laid in the city is 117521 feet, or 22.26 miles, of which all but 5052 feet, or less than one mile, are available for tapping. There are 133 stop valves, and 235 hydrants, of which 204 are Lowry, 16 Ludlow and 15 Matthews.

ENGINE HOUSE.

The channel of Coldbrook Creek has been covered with timber as far back as the stone walls extend, (112 feet from Canal Street,) and the grounds filled up to the level of Canal Street, back to the river. A wood shed has been built 102'x96' between centers of corner posts, which will hold 360 cords.

A neat fence on the south and east sides of the building and the sodding of the grounds would add much to their appearance.

SETTLING BASIN.

The inner slopes of the basin have been paved with cobble stones eight inches in depth, set on six inches of gravel. The bermes left on the original slopes were taken out as no longer necessary and the slope now stands at 2 2-5 horizontal to 1 vertical.

A brick gate house 17'10"x16'6" on the outside, 10 feet high in front and 12 feet in the rear, with gravel roof, has been built over the outlet chambers, and a picket fence six feet high built around the edge of the inner slope.

The reservoir, pumping machinery, and pipe under Grand River are all in good order and have required no additional expenditure for construction during the past year.

COST OF WATER WORKS.

The total expenditure for construction of the Water Works up to May 1st, 1877, is as follows:

	TO MAY 1ST 1875.	MAY 1, '75 TO MAY 1, '76	MAY 1, '76 TO MAY 1, '77	TOTAL.
Real Estate.........	$ 30,050.00	$ 15,312.50	$ 899.81	$ 46,262.31
Pipe System.........	122,799.28	52,480.54	24,423.83	199,703.65
Pipe under River...	2,004.75	2,616.68	....	4,621.43
Con't'ns with Pumps	364.37	....	....	364.37
Reservoir...........	51,401.88	3,264.38	....	54,666.26
Set. Bas. & Sup. Pipe	....	12,571.23	3,897.98	16,469 21
Engine House, Tem.	250.39	20.00	....	270.39
Engine House, Per.	19,209.06	3,549.36	1,117.48	23,875.90
Pump'g Mach'y, Per.	14,181.81	7,290.52	....	21,472.33
Pump'g Mach'y, Tem	2,331.75	....	....	2,331.75
Meters..............	....	825.62	2,223.75	3,049 37
Hose Heads.........	500.00	....	....	500.00
Engin'ng & Supt'nce	2,972.47	3,468.65	3,439.00	9,880.12
Print. & Advertising	152.50	40.05	58.14	250.69
Expenses of Loan...	462.96	189.69	125.01	777.66
Miscellaneous.......	276.83	289.80	....	566.63
Total..........	$246,958.05	$101,919.02	$ 36,185.00	$385,062.07

The amount of water bonds issued is $382,000 on which the annual interest will be $30,560.

The receipts of the Water Works Fund since the commencement of the works, are as follows:

	PREVIOUS TO MAY 1, '76	MAY 1, '76 TO MAY 1, '77.	TOTAL.
From Sale of Bonds.........	$ 342,060 52	$ 34,923 60	$ 376,984 12
From Bonds paid to Farrington & Branch.............	10,000 00	....	10,000 00
From priv. parties for Pipe, &c	171 58	178 32	349 90
From Far. & Branch, repairs.	....	86 58	86 58
....	$352,232 10	$ 35,188 50	$ 387,420 60

MAINTENANCE AND OPERATION OF WATER WORKS.

The receipts of the Water Works Income Fund have been as follows:

	TO MAY 1, 1875.	MAY 1, '75 to MAY 1, '76	MAY 1, '76 to MAY 1, '77	TOTAL.
From Permits.......	$ 1,060.00	$ 1,260.00	$ 668.00	$ 2,988.00
From Water Rents..	1,019.82	9,532.41	6,244.12	16,796.35
From Frontage Tax.	....	3,064.87	2,637.32	5,702.19
From General Tax..	....	6,000.00	....	6,000.00
....	$ 2,079.82	$19,857.28	$ 9,549.44	$31,486.54

The receipts during the past year have been considerably less than was anticipated, owing largely to the continual depression in business, which has prevented many from connecting with the mains who would otherwise have done so, and compelling economy on the part of those already connected. It cannot be expected that there will be any great increase during the coming year.

The expenditures have been as follows:

	TO MAY 1, 1875.	MAY 1, '75 to MAY 1, '76	MAY 1, '76 to MAY 1, '77	TOTAL.
Operating Expenses	$ 6,162 31	$ 7,778 52	$12,663.23	$26,604.06
Interest on Bonds..	17,637 73	26,280 00	29,280.00	73,197.73

During the past year the expenditures have have been:

For Pumping—Wages, Engineers and Fireman	$3,186 25	
Fuel—Wood and Coal	3,204 13	
Small Stores	273 89	
Repairs, Engine House	44 51	
Repairs, Engine and Boiler	67 08	
		$6,775 86
For Tapping—Wages, Tools, etc	$ 991 40	
Stop Cocks, etc	806 16	
		1,797 56
For Repairs—Labor, Materials, etc	$ 772 14	
Superintendence since 1874	1,612 00	
		2,384 14
For Office Expenses—Clerk's Salary	$ 812 50	
Stationery	116 77	
Printing	19 89	
		949 16
For Setting Meters, etc		253 89
For Sundries—Rent	$ 150 00	
Sewer Tax	214 27	
Cartage, Lumber, etc	117 71	
Taxes Refunded	20 65	
		502 63
Total		$12,663 23

The operating expenses seem to have increased largely since last year, but it is more in appearance than reality, as about $1,800 of the amount was for wages and superintendence of repairs, which belonged to previous years, some as far back as 1874, and about $1,400 for fuel and other materials now on hand, leaving only about $9,400 for the legitimate expenses of the year. Arrangements have been made by which a considerable reduction will be effected during the coming year, and it is probable that the expenses will not exceed $8,000.

Number of Permits issued previous to May 1, 1875	205
" " " " May 1st, 1875 to May 1st, 1876	257
" " " " May 1st, 1876 to May 1st, 1877	135
Total number issued	597

A license for general plumbing has been granted to William Miller. All licenses for tapping were revoked at the beginning of the year, and this work has since been done by an employee of the Board.

Forty-five meters have been purchased, making the present number 88 of which 71 are in use.

Ball & Fitts, 2 1½", 11 1", 33 ¾", 36 ⅝"—82.
Worthington, 2 1", 4 ⅝"—6.

Water is furnished for the following uses:

474 Street Sprinklers.
334 Water Closets.
52 Urinals.
23 Baths.
380 Sinks.
236 Families.

The above does not include consumers and fixtures supplied through meters.

WORK OF THE PUMPING ENGINE.

The engineer of the pumping works submits the following report:

GRAND RAPIDS, MAY 1ST, 1877.

To the Honorable Board of Public Works:

GENTLEMEN—The undersigned respectfully submits his report of fuel burned and work done for the year beginning May 1st, 1876 and ending April 30th, 1877.

Delivery of water per revolution, estimated at 100 gallons, 160 feet high.

Fuel is pine slabs and edgings, average weight, moderately dry, 1400 ℔s. to the cord. Estimated value of fuel, 2½ ℔s. of slabs=1 ℔. coal.

Steam is kept at about 15 ℔s. through the 24 hours when not running. Average time of running 8 hours in 24.

In the following statement the total amount of wood burned each month is given, no reduction being made for fuel expended in raising and keeping up steam.

The probable expenditure of fuel for other purposes than pumping is about one-fourth of the whole amount. It would therefore be correct to add for performance of engine one-third to the duty given, making the duty for February actually considerably larger than 71,573,980 as given. The wide difference in duty for different months is accounted for by difference in fuel and difference in running. Thus, in December, when a cord of slabs had half a cord of snow and ice on it, the duty was only 26 millions; again, in July when the paving of the settling basin was in progress, and the engine working from 15 to 25 minutes in each hour of the 24, the duty was a little over 30 millions. In February, with a regular supply of water, and slabs which had been under cover for a few weeks, and warm and dry weather, the duty rose to 71½ millions.

On the 18th of April, with 4725 lbs. of pine edgings and thin slabs, mere kindling wood in fact, the engine pumped one million gallons 160 feet high, giving a duty of over 71 millions. Time, 10 hours, 40 minutes, boiler pressure about 30 pounds. This is the only time made with weighed fuel.

From these figures it appears that for comparative economy of fuel, the engine at the Grand Rapids Pump House stands well up in the list, and it is believed that with a mate coupled to the same shaft, so that advantage could be taken of an early cut off, for which the valve gear of the engine is extremely well suited, a duty could be shown fully equal to that of any pumping engine in the United States.

I am pleased to report that the engine, boilers and pumps are in good order, and that no repairs further than renewing packing have been required.

Since connecting the pumps with the Settling Basin there has been no deficiency in the supply of water to the pump, except while the paving of the basin was going on, and no trouble with sand and gravel which previously were a source of annoyance.

STATEMENT OF WORK DONE.

MONTHS.	RUNNING TIME.		NO. OF REVOLU'NS.	GALLONS PUMPED.	CORDS WOOD.	Duty in lbs raised 1 ft. high by the equival't of 100 lbs. coal.
1876.	H.	M.				
May	166	45	173,726	17,372,600	78	53,009,014
June	177	55	181,234	18,123,400	94	45,887,448
July......	288	30	202,553	20,255,300	160	30,129,758
Aug.....	581	05	208,739	20,873,900	140	35,550,563
Sept	209	55	201,553	20,155,300	102	47,028,361
Oct......	201	15	201,825	20,182,500	106	45,814,275
Nov.....	176	50	178,286	17,828,600	100½	42,434,068
Dec	207	55	217,060	21,706,000	145½	26,047,200
1877.						
Jan	225	50	233,876	23,387,600	98	56,830,868
Feb	187	50	192,469	19,246,900	64	71,576,120
March...	203	00	209,594	20,959,400	81	61,620,636
April.. ..	181	05	178,328	17,832,800	87	49,266,000
Total	2807	55	2,379,243	237,924,300	1,256	

DEMETRIUS TURNER,
Engineer Pumping Works.

From the above report it appears that 237,924,300 gallons of water have been pumped during the year, showing an average daily consumption of 651,847 gallons, an increase of about 150,000 gallons over the preceding year. If this rate of increase should continue during the coming year, it is evident that by the end of the year the consumption will have reached the limit of the supply from Carrier Creek.

Measures should therefore be speedily taken either to keep the consumption within the limits of the present supply or to obtain an additional supply. Where this additional supply should be obtained is a question which requires thorough examination and careful surveys for its solution, as there are in the case of this city questions of relative economy connected with it which cannot be met by mere guess-work or assertion.

It is also very desirable that the water of Carrier Creek should be condemned from the settling basin to the springs at the head of the creek, so that it cannot be used for any other purpose before reaching the basin.

It would be good policy to lay a pipe from the springs to the basin, and thus shut off the surface water which is of inferior quality, and gives annoyance by roiling the water in the basin in time of showers.

Assuming the present population of the city at 32,000, the consumption for each person per day is about 20 gallons, and for each tap per day about 1000 gallons, including what is used for fire and other public purposes.

Respectfully submitted,

E. W. MUENSCHER,
City Engineer.

LIST OF WATER MAINS LAID IN 1876.

EAST SIDE.

STREET.	FROM	TO	SIZE.	LENGTH		KIND.
				ft.	in.	
Calder	Cherry	Island.....	6 inch	926	11	Cast Iron.
Cherry	Paris......	Henry.....	8 "	973	0	"
Cherry	Division...	Ionia......	8 "	624	1	"
Division....	Wealthy ..	5th Avenue	12 "	2650	7	"
Jefferson Av	Wealthy ..	Blakeley...	6 "	1067	5	"
Kent Alley.	Lyon......	Bridge.....	4 "	1140	7	"
Lagrave....	Maple.....	Wealthy ..	6 "	853	0	"
Paris Ave..	Cherry	Buckeye...	6 "	708	0	"
Plainfield A.	Leonard...	Quimby ...	8 "	1955	2	"
Ransom....	Lyon......	Fountain ..	4 "	710	4	"
Summit.....	Bartlett ...	Wealthy...	8 "	669	4	"
Wealthy Av	Summit ...	Grandville.	8 "	328	1	"
Wealthy Av	Division...	Lafayette..	10 "	1597	11	"
....	Branches to	Hydrants...	4 "	12	2	"
	Branches to	Hydrants...	6 "	27	6	"

WEST SIDE.

Bridge......	Stocking...	Indiana....	12 "	1304	8	"
Jefferson....	Sibley.....	Shawmut..	6 "	332	0	"
Stocking....	Bridge	Fourth	8 "	1885	11	"

TOTAL PIPE LAID.

	20"		16"		14"		12"		10"		8"		6"		4"		TOTAL.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Cast Iron	681	5	268	1	29	11	9795	7	4867	9	9735	3	11844	10	7332	7	44555	5
Wrought Iron	....		....		....		784	0	....		....		....		....		784	0
Wyckoff	....		2419	1	5746	11	16507	8	4295	4	9962	0	15248	3	6841	5	60998	8
Logs	....		....		....		....		....		....		8181	7	1141	0	9322	7
Stave	1860	0	....		....		....		....		....		....		....		1860	0
	2541	5	2687	2	5776	10	27087	3	9163	1	19697	3	35252	8	15315	0	117520	8

22.26 Miles.

Distribution—East Side, 86527'. West Side, 25942'. Not Tapped, 5051' 8".

LOCATION OF STOP VALVES SET IN 1876

STREET.	LOCATION.	PATTERN.	SIZE. INCHES.
Calder Street....	North line Cherry Street...	Eddy.	6
Cherry Street....	West " Henry " ...	"	8
Cherry Street....	West " Division " ...	"	8
Division Street..	South " Wealthy Avenue	"	12
Division Street..	North " Second "	"	12
Division Street..	North " Fifth "	"	12
Jefferson Avenue	South " Wealthy "	"	6
Kent Alley......	North " Lyon Street.....	"	4
Lagrave Street..	North " Wealthy Avenue	"	6
Paris Avenue....	South " Cherry Street...	"	6
Plainfield Ave...	North " E. Leonard St...	"	8
Plainfield Ave...	South " Madison Street..	"	8
Ransom Street...	South " Lyon "	"	4
Summit Street...	North " Wealthy Avenue	"	8
Wealthy Avenue.	East " Division Street..	"	10
Wealthy Avenue.	West " Jefferson Ave...	"	10
Wealthy Avenue.	East " Jefferson " ...	"	10
Wealthy Avenue.	East " Grandville Ave..	"	8
Bridge Street....	East " Indiana Street...	"	12
Jefferson Street..	North " Shawmut Ave...	"	6
Stocking Street..	North " Bridge Street...	"	8
Stocking Street..	South " Fourth " ...	"	8

LOCATION OF HYDRANTS SET IN 1876.

LOWRY HYDRANTS.

Intersection of Calder Street with Island.
" " Cherry " " Union, James and Henry.
" " Cherry " " Spring.
" " Division " " Wenham, Blakeley & Pleasant
" " Division " " Sycamore and 5th Avenue.
" " Jefferson Ave. " Blakeley.
" " Lagrave St. " Goodrich and Wealthy.
" " Paris Avenue " Buckeye.
" " Plainfield Ave. " Carrier, Page and Grove.
" " Plainfield " " Caledonia and Quimby.
" " Summit Street " Goodrich and Wealthy.
" " Wealthy Ave. " Sheldon, Cass and Lafayette.
" " Wealthy " " Grandville.
" " Bridge Street " Gold and West Broadway.
" " Bridge " " Straight and Indiana.
' " Stocking " " First, Second, Third & Fourth

LUDLOW HYDRANTS.

Northwest corner of Calder and Oakes Streets.
" " " Jefferson and Wenham Avenues.
Northeast " " Kent Alley and Bronson St.

REPORT

OF THE

BOARD OF PUBLIC WORKS,

TO THE

COMMON COUNCIL OF THE CITY OF GRAND RAPIDS,

Transmitting the Reports of the

Superintendent, Collector and Engineer

OF THE WATER WORKS,

For the Fiscal Year ending April 30th, 1878.

ALSO THE

Annual Report of City Surveyor.

GRAND RAPIDS, MICH.:
C. M. Loomis, Book and Job Printer.
1878.

REPORT

OF THE

BOARD OF PUBLIC WORKS,

TO THE

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Superintendent, Collector and Engineer

OF THE WATER WORKS.

COMPLIMENTS OF THE BOARD.

PLEASE EXCHANGE.

ALSO THE

Annual Report of City Surveyor.

GRAND RAPIDS, MICH.:
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1878.

REPORT

OF THE

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TO THE

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1878.

Report of the Board.

GRAND RAPIDS, MAY 1ST, 1878.

To the Honorable the Mayor and Council:

The Board of Public Works has the honor to submit herewith its report of the operation of the Water Works for the year ending April 30th, 1878.

The report of the Superintendent of the works, shows in detail the condition of things under his charge, and a complete inventory of the property belonging to the city, and especially in charge of the Board of Public Works.

The report of the Collector of Water Rates and Clerk of the Board, shows the receipts and expenditures for the year, and a detailed statement of all matters connected with the operation of the works that will in any way interest the public.

The Report of Mr. Demetrius Turner, engineer in charge of the pumping aparatus, follows with an inventory of the fuel and other property in his charge. These reports show a remarkable improvement in everything connected with the management of the works for which the city is largely indebted to the untiring vigilance of Mr. Turner, our engineer, and his assistants at the pump house, to Thos. Farmer, Jr. the Superintendent, and especially to Mr. A. B. Farnsworth, the late collector of water rates, and Clerk of the Board. Mr. Fred. A. Twamley the newly appointed Collector, has given the Board good satisfaction during the time he has discharged the duties of that office, and we think will be a faithful and valuable public servant. The Board has frequently called the attention of the Council to the propriety of an allowance to the Water Works Income Fund for water taken for public use. This would not in any way affect taxation or the treasury, but it would be a merited acknowledgment of the great benefit derived by the city from the water works. The cost of management and operation of the works has been reduced to the lowest point consistent with honest and efficient service, and in the general results of the operative department we challenge a comparison with any works in the country of equal capacity.

The income of the works has been $7,925.64 more than the operating expenses and salaries, and the cost of management ought not to increase hereafter as fast as the income.

The harmony that has existed between the Council and Board during the past year has made our position unusually pleasant, and it is gratifying to know that what little there may have been of factious opposition has not in any way been prejudicial to the public interests. The wise action of the Council in providing the means to purchase duplicate pumping machinery meets with the general approval of the taxpayers that have taken the trouble to look into the necessity for it. The contract has ben executed in accordance with the approval of the Council, and the work begun. The pay of the five members of the Board for the past year amounts to $265.50.

If this sum is deemed excessive for the service rendered. we respectfully suggest to the Council, that the duties of the Board may be profitably increased by placing in its charge the general care and supervision of the improved streets. There is such a general disregard of the ordinances governing the use of the streets, especially the ordinances forbidding driving in and across the paved gutters, depositing rubbish on the streets, and scattering dirt along the streets from open wagons, as to make a serious drain on the highway funds.

Some one should be authorized and required to prosecute the offenders.

Respectfully submitted.

THOS. D. GILBERT,
F. B. DAY,
JOHN S. FARR,
L. D. PUTNAM,
JAMES MILLER,
Board of Public Works.

Superintendent's Report.

WATER WORKS OFFICE,
MAY 1ST, 1878.

To the Honorable the Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—The annual report for the year ending April 30th, 1878, is herewith respectfully submitted.

There have been no extensions to the pipe system during the year. A new boiler has been set up at the Pumping Station, and the old one thoroughly overhauled. The expenses for maintenance and repairs have been less than for any previous year, while the receipts have been greater.

RESERVOIR.

Notwithstanding the fact that the outer slopes are not sodded, there are no signs of wash owing to rain storms, and there are no signs of leakage.

SETTLING BASIN.

The setling basin is in very good condition, but a small amount having been expended for repairs.

PIPE UNDER GRAND RIVER.

The pipe under Grand River, at Mason Street, was carefully inspected along its entire length, (during the period of low water) and found to be in perfect order, as no signs of leakage at the joints or of rust on the body of the pipe were discernable.

WYCKOFF PIPE.

The Wyckoff Pipe is, to all appearance, in as good condition as when laid. In uncovering the pipe for the purpose of tapping on making repairs, the iron bands appear to be as bright as when put on. The coating of coal tar on the outside of the pipe is very firm, with no appearance of scaling off.

PUMP LOGS.

The pump logs have given but little trouble during the year, and with the exercise of a proper amount of care in closing hydrants, will prove a very serviceable kind of pipe for the upper levels.

HYDRANTS AND VALVES.

There have been nine Lowry hydrants raised by extensions, in order to bring them to street grade. A large number of valve boxes have also been raised, but as the expense of each was small, no account was kept of the number The hydrant and valve boxes have also all been cleaned, and the hydrant barrels, and the caps of the valves have been painted with coal tar.

METERS.

The city now owns 88 meters, and there are also 10 meters loaned for trial. Of these there are 90 in use, as follows :

75 Ball & Fitts Piston.
3 " " Rotary, (loaned.)
6 Worthington.
6 Arnold's Patent, (loaned.)

A few meters must necessarily be kept on hand, to replace those taken out for repairs, and for the convenience of builders. A number of the Ball & Fitts Piston meters have stopped owing to the breakage of the crank shafts. The rotary meters are proving to be all that was claimed of them. One Worthington stopped registering, but aside from this, no trouble was experienced with this kind of meter.

LEAKS.

The following table shows the number and kind of leaks in the different pipes:

	Joints.	Knots.	Checked.	Bands Burst.	Total.
Wyckoff,	14	8	1		23
Pump Logs,		1	3		4
Iron,	2				2
Stave,		1		4	5
Total,	16	10	4	4	34

There have been three new valve stems put in to replace broken ones, as follows: one four-inch at Phœnix Furniture Co., one four-inch at Star Mills, one four-inch at intersection of Fountain and Division Sts. Five hydrant valves have been taken out, which were badly cut up by stones getting in the valve seats, and replaced by leather ones. One Ludlow hydrant was found frozen, and so damaged as to require taking up and replacing by a new one. During the year a small repair shop has been built and fitted up with tools necessary for repairing meters, hydrants, &c. It has been the means of considerable saving to the city.

The annexed tables show the streets in which the pipe is laid, the kind of pipe, and location of hydrants and valves.

An inventory of stock and tools is also appended.

Respectfully submitted,

THOMAS FARMER, Jr.,
Superintendent.

LIST OF WATER MAINS.—May 1st, 1878.

EAST SIDE.

STREET.	FROM	TO	Size	LENGTH.			
				Cast Iron.	WYCKOFF	Logs.	Total.
			In.	Ft. In.	Ft. In.	Ft. In	Ft. In.
Barclay	Bridge	Bronson	14	3-4	513-4		516-8
"	Bronson	Lyon	4	3-4		546-8	550-0
"	Fountain	Fulton	4	824-7			824-7
Bostwick	Fountain	Lyon	4	689-2			689-2
E Bridge	Canal	Ottawa	12	605-0			605-0
"	Ottawa	Colt Ave	12	27-7	1503-0		1530-7
"	Colt Ave	Barclay	14	2-2	182-3		184-5
"	Barclay	N Lafayette	10	519-9			519-9
Bronson	Barclay	N Lafayette	14	2-2	498-7		500-9
"	N Lafayette	N Union	6	19-1		1972-11	1992-0
Calder	Cherry	Island	6	926-11			926-11
Campau	Pearl	Co Jail	4	7-7	435-7		443-2
Canal	Pearl	E Bridge	10	1496-0			1496-0
"	Pumping Sta.	E Leonard	12	5-6	825-11		831-5
"	E Leonard	R S & Co's Mill	8	22-1	2136-1		2158-2
"	R S & CO'S MILL	N City limits	6	4-4	431-8		436-0
Cherry	Summit	S Ionia	8	902-0			902-0
"	Jefferson Ave	S Lafayette	8	5-4	652-4		657-8
"	S Lafayette	Paris Ave	8	1665-0			1665-0
"	Paris Ave	Henry	8	973-0			973-0
"	S Division	S Ionia	8	624-1			624-1
Clancy	E Bridge	Hastings	6	4-5		663-7	668-0
Clinton	E Bridge	Hastings	6	603-5			603-5
"	Hastings	Fairbanks	6	5-5		1140-0	1145-5
Coit Ave	E Bridge	Hastings	14	3-4	600-3		603-7
"	Hastings	Trowbridge	6	8-5		566-7	575-0
N & S Division	E Bridge	Cherry	12	28-5	3928-9		3957-2
S Division	Cherry	Wealthy Ave	12	19-5	1286-7		1306-0
"	Wealthy Ave	Fifth Ave	12	2650-7			2650-7
Erie	Canal	Leitelt's Shops	4	181-0			181-0
Fountain	N Division	Barclay	4	1151-5			1151-5
"	N Lafayette	Grand Ave	6	19-3		2530-7	2549-10
E Fulton	Division	Prospect	10	21-10	2052-4		2074-2
Hastings	Coit Ave	Livingston	14	2-2	403-0		405-2
Huron	Canal	Butterworth	4	294-0			294-0
N & S Ionia	Pearl	Oakes	6	20-11	2081-1		2102-0
S Ionia	Oakes	Cherry	6	475-4			475-4
Jefferson Ave	E Fulton	Wealthy Ave	6	19-6	2615-9		2635-3
"	Wealthy Ave	Blakely Ave	6	1067-5			1067-5
Kent	Lyon	E Bridge	6	1140-4			1140-4
"	E Bridge	Trowbridge	6	8-4	1160-5		1168-9
"	Trowbridge	Mason	6	1701-0			1701-0
Kent Alley	Lyon	E Bridge	4	1140-7			1140-7
N Lafayette	Bronson	Lyon	14	2-2	549-3		551-5
"	Lyon	E Fulton	8	8-8	1565-9		1574-5
S Lafayette	E Fulton	Cherry	4	7-7	1336-3		1343 10
Lagrave	E Fulton	Maple	6	1784-11			1784-11
"	Maple	Wealthy Ave	6	853-0			853-0
Ledyards Alley	Pearl	S in rear of bldg	6	2-2	170-0		172-2
E Leonard	At Canal		12	3-3	33-11		37-2
"	Canal	Plainfield Ave	12	8-0	896-8		904-8
Livingston	Reservoir	Newberry	20	272-3			272-3
"	Newberry	Hastings	14	6-6	1691-4		1697-10
Lewis	N Waterloo	Campau	4	2-2	427-2		429-4
Lyon	N M & Co	Canal st	6	445-0			445-0
"	Canal	Ottawa	10	15-5	582-2		597-7
"	Ottawa	N Division	10	508-5			508-5
"	N Division	N Lafayette	10	16-5	1660-10		1677-3
"	N Lafayette	N College Ave	14	8-1	1308-11		1317-0
Mason	Reservoir	Ottawa	16	70-10	894-8		965-6
"	Ottawa	Canal	12	9-11	601-6		611-5
Monroe	Pearl	Ottawa	10	692-0			692-0
"	Ottawa	N Division	12	801-4			801-4
Ottawa	Monroe	Newberry	12	4254-3			4254-3
"	Newberry	Mason	12	9-5	572-2		581-7
"	Mason	Pumping Sta.	16	88-3	1524-5		1612-8
Paris Ave	Cherry south		6	708-0			708-0

LIST OF WATER MAINS.—May 1st, 1878.

EAST SIDE.

STREET.	FROM	TO	Size	LENGTH.			
				Cast Iron.	WYCKOFF	Logs.	Total.
			In.	Ft. In.	Ft. In.	Ft. In	Ft. In.
Pearl	N Division	Near river	6	28-10	1536-6		1565-4
Plainfield Ave.	E Leonard	Quimby	8	1955-2			1955-2
N Prospect	E Fulton	Lyon	6	291-1		1307-11	1599-0
Ransom	E Fulton	Fountain	4	823-8			823-8
"	Fountain	Lyon	4	710-4			710-4
"	Bronson	E Bridge	4	4-4		594-4	598-8
Sheldon	E Fulton	Oakes	6	859-7			859-7
Summit	Cherry	Bartlett	8	660-5			660-5
"	Bartlett	Wealthy Ave	8	669-4			669-4
Washington	S Lafayette	S College Ave	4	1319-9			1319-9
N Waterloo	Monroe	E Fulton	8	11-8	1037-9		1049-0
Wealthy Ave.	Summit	Grandville Ave	8	828-1			828-1
"	S Division	S Lafayette	10	1597-11			1597-11

WEST SIDE.

Allen	Summer	Winter	8	3-3	291-2		294-5
W Bridge	Front	Stocking	12	28-6	2000-9		2029-3
"	Stocking	Indiana	12	1304-8			1304-8
Broadway	W Bridge	Eighth	12	19-8	2847-3		2866-11
Eighth	Broadway	N Front	12	9-4	930-8		940-0
Fifth	Broadway	Seward	6	8-8	863-6		872-2
S Front	W Bridge	Shawmut Ave.	6	19-6	1650-7		1670-1
Jefferson	W Bridge	Sibley	4	10-10	1308-5		1319-3
"	Sibley	Shawmut Ave.	6	332-0			332-0
Scribner	W Bridge	Eighth	6	17-4	2821-8		2839-0
"	Eighth	Webster	8	20-7	4217-9		4238-4
Shawmut Ave.	S Front	Jefferson	6	16-6	1779-0		1795-6
Stocking	W Bridge	Fourth	8	1885-11			1885-11
Summer	W Bridge	G R & I R R.	4	11-11	2147-7		2159-6
Third	Broadway	Seward	4	6-6	817-2		823-8
Winter	Allen	Shawmut Ave.	4	5-5	469-0		474-5

WATER MAINS, May 1st, 1878.

Not available for service connections.

STREET.	LOCATION.	Size.	LENGTH.				
			Cast Iron.	W't Iron.	WYCKOFF	Stave.	Total.
Allen	Blow off	8	1-1		61-2		62-3
Coldbrook	Supply Basin to Pump. Sta	20	132-10			1860-0	1992-10
Pumping Sta.	Supply Pipes	20	72-1				72-1
Erie	Branch to Pump, Leitelt's	4	19-0				19-0
S. Front	" " Brush Factory	6	1-1		44-5		45-6
"	" " Powers' Pump	4	1-1		44-2		45-3
"	" " Star Mills	4	1-1		55-10		56-11
Grand River	Canal St. to North Front	12	1-2	784-0	40-9		825-11
Huron	Branch to Butterworth's	4	80-6				80-6
Livingston	Under Reservoir bank	20	77-3				77-3
Lyon	Blow off	6	24-0				24-0
"	Branch to Nelson & Matter	4	42-0				42-0
Mason	Under Reservoir bank	16	109-0				109-0
"	Ionia to River waste	12	2-8		1039-9		1042-5
Newberry	Branch to Comstock's	12	7-0				7-0
"	" " "	4	32-7				32-7
Supply Basin	Carrier Creek inlet	20	63-6				63-6
" "	Coldbrook " "	20	63-6				63-6
	Branches to hydrants	4	12-2				12-2
	" " "	6	428-0				428-0

TOTAL PIPE LAID.

	20"	16"	14"	12"	10"	8"	6"	4"	TOTAL.
Cast Iron........	681-5	268-1	29-11	9795-8	4867-9	9735-8	11843-9	7332-7	44554-5
Wrought Iron......	....	....	....	784-0	....	....	....	....	784-0
Wyckoff.........	....	2419-1	5746 11	16507-8	4295-4	9962-0	15154-7	7041-2	61126-9
Logs	....	....	....	....	....	....	8181-7	1141-0	9322-7
Stave	1860-0	....	....	....	....	....	....	....	1860-0
TOTAL.	2541-5	2687-2	5776-10	27087-4	9163-1	19697-8	35179-11	15514-9	117647-9

= 22.28 Miles.

LOCATION OF HYDRANTS, MAY 1, 1878.

MATTHEWS HYDRANTS.

South West Cor. of E. Bridge and Kent.
" " " " " Canal.
North West " Canal " Erie.
" " " " " Huron.
" " " " " Lyon.
" " " " " Pearl.
South East " Monroe " N. Waterloo.
" " " " " Ottawa.
" " " " " N. Ionia.
" " " " " N. Spring.
North West " Ottawa " E. Bridge.
" " " " " Hastings.
" " " " " Trowbridge.
" " " " " Fairbanks.
South West " " " Newberry.
Total, 15.

LUDLOW HYDRANTS.

North West Corner of Lyon and N. Ionia.
" " " " " N. Division.
North East " Ottawa " Fountain.
North West " " " Pearl
" " " " " Lyon.
" " " " " Bronson.

North West Corner of Cherry and Lagrave.
West side Kent, between Lyon and Bronson.
“ “ “ “ Bronson and Bridge.
“ “ “ “ Trowbridge and Fairbanks.
“ “ “ “ Fairbanks and Newberry.
“ “ “ “ Newberry and Mason.
North side Cherry, at Paris Avenue.
North West corner of Calder and Oakes.
“ “ “ Jefferson Avenue and Wenham Avenue.
North East “ Kent Alley and Bronson St.
Total, 16.

LOWRY HYDRANTS.

Intersection of Calder with Island.
“ Cherry “ Union.
“ “ “ James.
“ “ “ Henry.
“ “ “ S. Spring.
“ S. Division with Wenham Avenue.
“ “ “ Blakely Avenue.
“ “ “ Pleasant St.
“ “ “ Sycamore.
“ “ “ Fith Avenue.
“ Jefferson Avenue with Blakely Avenue.
“ Lagrave with Goodrich.
“ “ “ Wealthy Avenue.
“ Paris Avenue with Buckeye St., produced.
“ Plainfield Avenue with Carrier St.
“ “ “ “ Page.
“ “ “ “ Grove.
“ “ “ “ Caledonia.
“ “ “ “ Quimby.
“ Summit with Goodrich.
“ “ “ Wealthy Avenue.
“ Wealthy Avenue with Sheldon St.
“ “ “ “ Cass.
“ “ “ “ S. Lafayette.
“ “ “ “ Grandville Avenue.

Intersection of West Bridge with Gold.
“ “ “ “ W. Broadway.
“ “ “ “ Straight.
“ “ “ “ Indiana.
“ Stocking with First.
“ “ “ Second.
“ “ “ Third.
“ “ “ Fourth.
“ Barclay “ E. Bridge.
“ “ “ Bronson.
“ “ “ John.
“ E. Bridge “ N. Ionia.
“ “ “ N. Division.
“ “ “ Clinton.
“ “ “ Livingston.
“ “ “ Coit Avenue.
“ E. Bridge “ N. Lafayette St.
“ W. Bridge “ Front.
“ “ “ Scribner.
“ “ “ Turner.
“ “ “ Broadway.
“ “ “ Seward.
“ “ “ Jefferson.
“ Broadway “ First.
“ “ “ Second.
“ “ “ Third.
“ “ “ Fourth.
“ “ “ Fifth.
“ “ “ Sixth.
“ “ “ Seventh.
“ “ “ Eighth.
“ Bronson “ N. Prospect.
“ “ “ N. College Avenue.
“ “ “ N. Union.

In Bronson, bet. N. Prospect and N. College Ave.

Intersection of Canal with E. Leonard.
“ “ “ Quimby.

In “ South of Barrel Co.'s Works.

In Canal North of Barrel Co.'s Works.
" " bet. Quimby Street and North limits.
Intersection of Cherry with Summit.
" " " Calder.
" " " Almy.
" " " S. Ionia.
" " " Luce.
" " " S. Lafayette.
" " " S. Prospect.
" " " Madison Avenue.
" " " S. College Avenue.
" Clinton " Hastings.
" " " Trowbridge.
" " " Fairbanks.
" Coit Ave. " Trowbridge.
" N. Division " Bronson.
" " " Pearl.
" " " Fountain.
" " " Park.
" " " E. Fulton.
" S. Division " Island.
" " " Oakes.
" " " Cherry.
" " " Maple.
" " " Goodrich.
" " " Wealthy Avenue.
" Eighth with Turner.
" " " Scribner.
" " " N. Front.
" Fifth " Seward.
In Fifth, bet. Seward and Broadway.
Intersection of Fountain with Bostwick.
" " " " Ransom.
" " " " Barclay.
" " " " N. Lafayette.
" " " " N. Prospect.
" " " " N. College Avenue.
" " " " N. Union.

Intersection of Fountain with Grand Avenue.

In Fountain between N. Prospect and N. College Ave.

Intersection of S. Front with Bowery.
“ “ “ “ Valley.
“ “ “ “ Allen.
“ “ “ “ Shawmut Avenue.
“ “ E. Fulton “ Sheldon.
“ “ “ “ Ransom.
“ “ “ “ Barclay.
“ “ “ “ Lafayette.
“ “ “ “ Prospect.
“ “ Hastings “ Clancy.
“ “ “ “ Coit Avenue.
“ “ “ “ Livingston.
“ “ N. Ionia “ Pearl.
“ “ “ “ Fountain.
“ “ “ “ Louis.
“ “ “ “ E. Fulton.
“ “ S. Ionia “ Island.
“ “ “ “ Oakes.
“ “ Jefferson Avenue with Island St.
“ “ “ “ “ Oakes.
“ “ “ “ “ Cherry.
“ “ “ “ “ Maple.
“ “ “ “ “ Goodrich.
“ “ “ “ “ Wealthy Avenue.
“ “ Jefferson St. with Bowery.
“ “ “ “ Chatham.
“ “ “ “ Jackson.
“ “ “ “ Sibley.
“ “ “ “ Shawmut.
“ “ Kent “ Bronson.
“ “ “ “ Lyon.
“ “ “ “ Hastings.
“ “ “ “ Trowbridge.
“ “ “ “ Fairbanks.
“ “ “ “ Newberry.
“ “ S. Lafayette “ Washington.

Intersection of N. Lafayette with John.
“ “ “ “ Bronson.
“ “ Lagrave “ Island.
“ “ “ “ Oakes.
“ “ “ “ Maple.
“ “ Livingston “ Trowbridge.
“ “ “ “ Fairbanks.
“ “ “ “ Newberry.
“ “ Louis “ Campau.
“ “ E. Leonard “ N. Ionia, produced.
“ “ “ “ Taylor.
“ “ “ “ Plainfield Avenue.
“ “ Lyon “ Bostwick.
“ “ “ “ Ransom.
“ “ “ “ Barclay.
“ “ “ “ N. Lafayette.
“ “ “ “ N. Prospect.
“ “ “ “ N. College Avenue.

In Lyon between N. Prospect and N. College Ave.

Intersection of Mason with N. Ionia.
“ “ “ “ Kent.
“ “ “ “ Canal.
“ “ Ottawa “ Mason.
“ “ “ “ Walbridge.
“ “ “ “ Coldbrook.
“ “ Pearl “ Campau.
“ “ “ “ Arcade.
“ “ Ransom “ Bronson.
“ “ “ “ Park.
“ “ Scribner “ First.
“ “ “ “ Second.
“ “ “ “ Third.
“ “ “ “ Fourth.
“ “ “ “ Fifth.
“ “ “ “ Sixth.
“ “ “ “ Tenth.
“ “ “ “ Eleventh.

Intersection of Scribner with Twelfth.
“ “ “ “ W. Leonard.
“ “ “ “ Crosby.
“ “ “ “ Myrtle.
“ “ “ “ Webster.
“ “ Shawmut Avenue with Court.
“ “ “ “ “ Mt. Vernon.
“ “ “ “ “ W. Division.
“ “ Sheldon with Island.
“ “ “ “ Oakes.
“ “ Summer “ Bowery.
“ “ “ “ Allen.
“ “ “ “ Shawmut Avenue.
“ “ “ “ G. R. & I. R. R.
“ “ Summit “ Williams.
“ “ “ “ Bartlett.
“ “ Third “ Alabama.
“ “ “ “ Seward.
“ “ Washington with S. Prospect.
“ “ “ “ Madison Avenue.
“ “ “ “ S. College Avenue.
“ “ N. Waterloo “ Louis.
“ “ “ “ Ferry.
“ “ “ “ E. Fulton.
“ “ Winter with Allen.
“ “ “ “ Shawmut.

In center of Section 8, Campau Plat.

Total, 204.

Mathews, 15; Ludlow, 16; Lowry, 203.—Total, 234.

LOWRY HYDRANT BASES.

Intersection of E. Bridge with Bostwick.
“ “ “ Ransom.
“ W. Bridge “ Alabama.
“ Canal “ Le Grand.
“ “ “ the force main.
“ Clinton “ Mason.
“ N. Division “ Lyon.

Intersection of	S. Lafayette	with	Monroe.
“	S. Front	“	branch to Powers Mill.
“	E. Fulton	“	E. Park Place.
“	“	“	W. Park Place.
“	“	“	Lagrave.
“	“	“	Jefferson Avenue.
“	S. Lafayette	“	State.
“	Lyon	“	Kent Alley.
“	Mason	“	branch to old pump.
“	Pearl	“	Ledyard Alley.
“	Scribner	“	Ninth.
“	Summer	“	Valley.

Total, 19.

LIST OF STOP VALVES.—May 1st, 1878.

STREET.	LOCATION.	PATTERN.	SIZE. inches
Barclay	South line of E. Bridge	Lowry	14
"	North " " Lyon	Flowers	4
"	" " " E. Fulton	Eddy	4
Bostwick	South " " Lyon	"	4
E. Bridge	West " " N. Division	Lowry	12
"	" " " Coit Avenne	"	12
"	East " " Barclay	Eddy	10
W. Bridge	" " " Front	Lowry	12
"	" " " Summer	"	12
"	" " " Indiana	Eddy	12
"	West " " Broadway	Lowry	12
"	" " " Stocking	"	12
Broadway	North " " W. Bridge	"	12
"	South " " Eighth	"	12
Bronson	East " " N. Lafayette	Flowers	6
"	West " " N. Union	"	6
Calder	North " " Cherry	Eddy	6
Canal	South " " Lyon	Ludlow	10
"	" " " E. Bridge	"	10
"	At Pumping Station	Lowry	12
"	North line of E. Leonard	"	8
"	" limits of City	"	6
Cherry	East line of Summit	Eddy	8
"	West " S. Lafayette	Lowry	8
"	East " "	Eddy	8
"	West " College Avenue	"	8
"	" " Henry Street	"	8
"	" " S. Division	"	8
Clancy	North " E. Bridge	Flowers	6
Clinton	" " E. Bridge	Eddy	6
Coit Ave	" " E. Bridge	Lowry	14
"	" " Hastings	Flowers	6
N. Division	South " E. Bridge	Lowry	12
S. Division	" " Lyon	"	12
"	" " E. Fulton	"	12
"	" " Cherry	Eddy	12
"	North " Wealthy Avenue	"	12
"	South " "	"	12
"	North " Second Avenue	"	12
"	" " Fifth Avenue	"	12
Eighth	West " Scribner	Lowry	12
"	East " North Front	"	12
Erie	On branch to Leitelt's Shop	Ludlow	4
Fifth	West line of Broadway	Lowry	6
Fountain	East " N. Division	Eddy	4
"	" " N. Lafayette	Flowers	6
"	" " N. College Avenue	"	6
S. Front	South " W. Bridge	Lowry	6
"	On Branch to Brush Factory	"	6
"	" " Powers' Mill	"	4
"	" " Star Mills	"	4
E. Fulton	East line of Division Street	"	10
"	West " Lafayette	"	10
N. Ionia	East " Monroe	"	6
"	West " "	"	6
Jefferson Ave	South " Wealthy Avenue	Eddy	6
"	" " E. Fulton	Lowry	6
"	North " Wealthy Avenue	"	6
Jefferson St	South " W. Bridge Street	"	4
"	North " Shawmut Avenue	Eddy	6
Kent Alley	" " Lyon	"	4
Kent St	" " "	"	6
"	South " E. Bridge	"	6
"	North " "	Lowry	6
"	South " Mason	Eddy	6
N. Lafayette	North " E. Fulton	Lowry	8
"	South " Lyon	"	8
Lagrave	North " Wealthy Avenue	Eddy	6
"	South " E. Fulton	"	6
"	" " Cherry	"	6
E. Leonard	East " Canal	"	12
Livingston	Foot of Reservoir bank	Lowry	20
Lyon	West line of Ottawa	"	10

LIST OF STOP VALVES.—May 1st, 1878.

STREET.	LOCATION.	PATTERN.	SIZE. Inches
Lyon	West line of N. Division	Lowry	10
"	East " "	"	10
"	West " N. Lafayette	"	10
"	East " "	Eddy	14
Mason	Foot of Reservoir bank	Lowry	16
"	East line of Ionia on Waste	"	12
"	" " Ottawa Street	"	16
"	West " "	"	12
"	" " Canal Street	"	12
Monroe	" " N. Division	Ludlow	12
"	" " Ottawa	"	10
Ottawa	North " Monroe	"	12
"	South " E. Bridge	"	12
"	North " "	"	12
"	South " Newberry	"	12
"	North " Mason	Lowry	16
"	South " Coldbrook	"	16
"	On connection with Comstock's Pipe	Ludlow	4
Paris Ave	South line of Cherry Street	Eddy	6
Pearl St	West " N. Division	Lowry	6
"	" " Ottawa	"	6
"	" " Canal	"	6
Plainfield Ave	North " E. Leonard	Eddy	8
"	South " Madison Street	"	8
N. Prospect	North " E. Fulton	"	6
"	South " Lyon Street	Flowers	6
Ransom	" " "	Eddy	4
"	North " E. Fulton	"	4
"	South " E. Bridge	Flowers	4
Scribner	North " W. Bridge	Lowry	6
"	South " Eighth	"	6
"	North " "	"	8
"	South " W. Leonard	"	8
"	North " "	"	8
Shawmut Ave	West " S. Front	Ludlow	6
"	East " Summer	Flowers	6
"	" " Jefferson	Lowry	6
Sheldon	South " E. Fulton	Eddy	6
Stocking	North " W. Bridge	"	8
Summer	South " "	Lowry	4
"	North " Shawmut Avenue	Eddy	4
Summit	South " Cherry	"	8
"	North " Wealthy Avenue	"	8
Stocking	South " Fourth Street	"	8
Third	West " Broadway	Lowry	4
Washington	" " S. College Avenue	Eddy	4
"	East " S. Lafayette	"	4
N. Waterloo	South " Monroe	Lowry	8
Wealthv Ave	East " S. Division	Eddy	10
"	West " Jefferson Avenue	"	10
"	East " "	"	10
"	" " Grandville Avenue	"	8
Winter	North " Shawmut Avenue	"	4
Pumping Station	North end Supply Pipe	Lowry	20
" "	South " "	"	20
" "	On Branch to Well	"	20
Setting Basin	On Carrier Creek Inlet	Eddy	20
" "	On Coldbrook " "	"	20
" "	On Outlet	"	20

Total, 132.

LOCATION OF SAFETY VALVES.

On Lyon Street, 24 feet east of Dock.

On Allen Street, at Tail Race.

Collector's Report.

OFFICE OF THE BOARD OF PUBLIC WORKS,
GRAND RAPIDS, MICH., MAY 1ST, 1878.

To the Honorable the Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—I respectfully present the following report for the year ending April 30th, 1878.

The number of services on the 1st of May, 1877, for which permits were issued, were	597
Taps granted without permits,	13
Private mains connected with works,	15
Total,	625
Number of services put in the past year, For all but one permits were issued.	94
Total number of connections on May 1st, 1878,	719
Number of services now cut off,	68
Number of services now open,	651

The receipts for the past year have been considerably more than was estimated, owing largely to the prompt payment of assessments, and to the fact that one-half the annual rate for sprinklers and fountains was for the first time collected during the past month.

The receipts at this office for the year have been as follows:

From Water Rates,	$14,634.14
" " Permits,	473.23
Total income from Water Works,	$15,107.37
There has also been received:	
From Farrington & Branch, for Repairs,	45.33
" H. E. Thompson, for pipe laid in Fountain St.	44.27
" Sewer Permits,	34.50
Total receipts for the year,	$15,231.47

Deposits have been made with the City Treasurer during the year as follows:

To the credit of Water Works Income Fund,	$14,979.80
“ “ “ “ 1st District Sewer Fund,	36.00
“ “ “ “ 2d “ “ “ .	6.00
Total deposits during the year, ...	15,021.80
Cash on hand to balance, . .	209.67
	$15.231.47

Receipts previous to May 1st, 1877:

From Water Rates, ...	$16,796.35
“ “ Permits, ...	2,988.00
“ Sewer “ . . .	196.50
“ Carter & Sullivan, account Iron pipe, .	97.62
“ G. R. Gas Co. 4 inch Valve, .	30.00
“ G. R. & I. R. R. Co., Pipe, . .	50.70
“ Farrington & Branch, Repairs, . .	86.58
Total, . . .	$20.245.75
Receipts for the past year, . .	15,231.47
Total receipts to date, .	$35.477.22

Deposits made previous to May 1st, 1877:

To the credit of Water Works Income Fund,	$19,980.85
“ “ “ “ “ Fund, .	264.90
Total, ...	20,245.75
Deposits made the past year, . .	15,021.80
Cash on hand to balance, . . .	209.67
Total, ...	$35,477.22

STATEMENT OF EXPENDITURES,

May 1st, 1877, to May 1st, 1878.

CONSTRUCTION OF WATER WORKS.

1. Pipe System.

Freight,	$ 37.80	
Repairs,	4.11	
Pipe,	340.56	
Pipe, (Farrington & Branch contract,)	132.00	
Pipe and Laying, (Temple Judgment,)	1,350.00	
Trip to Bay City, (Temple suit,)	16.12	
Cartage,	2.00	$1882.59

2. Settling Basin and Supply Pipe.

Wire Screens,	$ 12.00	
Carpenter Work,	12.94	
P. Grangers' Claim,	100.00	$124.94

3. Pumping House Grounds.

Filling Grounds,	$70.95

4. Pumping Machinery.

Labor on Boiler,	$ 10.00	
Repairs and Supplies, (Pump,)	105.62	
New Boiler,	3,360.50	$3,476.12

5. Printing and Advertising.

Advertising,	$ 8.16
Total amount paid on construction,	5,562.76
Paid previous to May 1st, 1877,	385,062.07
Total paid for construction to date,	$390,624.83

MAINTENANCE AND OPERATION OF WATER WORKS.

1. Pumping.

Salary Engineer,	$ 750.50
" Assistant Engineer,	720.50
Fireman	547.50
Fuel,	2,002.70
Repairs to Pumping Machinery,	125.46
" Boiler,	236.06
" " Arches,	28.00
" Engine House,	14.65
Supplies, (oils, packing, etc.,)	246.71
	$4,672.08

2. Office and Collecting.

Salary, Collector,	$675.00
" Asst. Collector, (8 months,)	312.00
Printing and Advertising,	57.02
Stamps and Stationery,	43.09
Freight and Telegraph,	31.12
	$1,118.23

3. Superintendence and Repairs.

Salary Superintendent,		$772.50

REPAIRS.

1. IRON PIPE.		
Labor,	$ 8.41	
Material,	26.51	34.92
2. WYCKOFF PIPE.		
Labor,	$79.24	
Material,	19.64	98.88
3. PUMP LOGS.		
Labor,	$16.77	
Material,	38.45	55.22
4. SUPPLY PIPE.		
Labor,	$35.93	
Material,	7.60	43.53
Carried forward,		$1,005.05

Brought forward,		$1,005.05
5. VALVES.		
Labor,	$12.25	
Material,	11.65	23.90
6. HYDRANTS.		
Labor,	$61.28	
Material,	94.71	155.99
7. METERS.		
Labor,	$46.32	
Material,	36.47	82.79
8. RESERVOIR.		
Labor,		5.88
9. SETTLING BASIN.		
Labor,		10.25
10. SUPPLIES, ETC.		
Tools,	$60.48	
Tapping Material,	2.17	
Blowing Off,	20.28	
Fitting up Shop,	20.63	
Engineering,	4.00	107.56
		1,391.42

RECAPITULATION.

Pumping,	$ 4,672.08
Office and Collecting,	1,118.23
Superintendence and Repairs,	1,391.42
Total paid for maintenance and operation,	7,181.73
Paid previous to May 1st, 1877,	26,604.06
Total paid to date,	$33,785.79
Income from the Works for the year,	$15,107.37
Cost of maintenance and operation,	7,181.73
Excess of receipts over expenditures.	$7,925.64

The cost of repairs to Wyckoff pipe is to be paid by Farrington & Branch, contractors, who laid this pipe in 1874 and 1875, and under the conditions of both contracts, are to keep the pipe in repair for five years.

Respectfully submitted,

FRED A. TWAMLEY, Collector.

STATEMENT

Showing the uses for which water is now supplied.

Bakeries,	4
Butcher Shops,	8
Breweries,	6
Bottling Works,	5
Blacksmith Shops,	3
Boarding Houses,	9
Barber Shops and Baths,	9
Banks,	5
Boilers,	17
Book Binderies,	2
Building Purposes,	8
Churches,	3
Dwellings,	210
Dye Houses,	2
Families in Blocks,	165
Fountains, (Stationary and Portable,)	35
Fire Protection,	15
Fire Engine Houses,	6
Green Houses,	2
Hospitals,	2
Hotels,	6
Halls,	5
Jail,	1
Laundries,	2
Library,	1
Manufactories,	17
Motor,	1
Machine Shops and Foundries,	3
Offices,	97
Photograph Galleries,	7
Printing Offices,	7
Post Office,	1
Restrauants,	7
Steam Engines,	11
Stores,	108
Street and Lawn Sprinklers,	389
Saloons,	35
Schools, (Public,)	4
Schools, (Private,)	1
Stables, (Public,)	21
Stables, (Private,)	46
Watering Troughs	5

STATEMENT

Showing number of fixtures connected with the Works.

	To May 1st, 1877.	Since May 1st, 1877.	Total to date
Bath Tubs, - - - - - -	49	20	69
Water Closets, - - - - -	439	103	542
Set Wash Basins, - -	116	27	143
Sinks, - - - - - -	394	79	473
Urinals, - - - - -	82	24	106
Fountains, (Stationary,) - -	18	2	20
Private Hydrants and Hose Connections,	619	128	747
Draw Cocks, - - - - -	57	23	80
Stationary Wash Tubs, - -	17		17
Boiler Connections, - - -	18	7	25
Tank Connections, - -	10	1	11

Engineer's Report.

GRAND RAPIDS MICHIGAN, MAY 1, 1878.

To the Honorable the Board of Public Works of the City of Grand Rapids.

GENTLEMEN—I submit herewith my annual report of the work done by the pumping engine for the year ending April 30, 1878.

The engine has been running on 322 days, making a total of time run, 2,282 hours and 45 minutes, against 2,807 hours and 55 minutes run the year previous.

The total number of revolutions made was 2,567,671, against 2,379,243 the year previous. The new boiler put in during the year gives good results.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, and the amount of wood burned.

The estimated quantity of water pumped per revolution is 97.82 gallons.

STATEMENT

Of work done by Pumping Engine for the year ending April 30th, 1878.

MONTH.	Days PUMPED.	TIME. H. M.	No. of REV'LUT'NS	Galls. Water Pumped.	Cords of Wood used.	Cost of wood used
May,	27	201-55	208,901	19,945,595	95.5	$143.25
June,	27	198-40	211,298	20,669,170	95.	142.50
July,	29	213-20	238,427	23,322,930	102.	153.00
August,	30	205-15	235,434	23,060,154	104.	156.00
September,	25	179-10	207,771	20,324,159	88.	132.00
October	27	174-45	203,654	19,921,434	88.	132.00
November,	27	180-20	200,800	19,642,256	100.	150.00
December,	27	179-55	208,063	19,863,622	91.	136.50
January	27	197-45	224,513	21,961,861	107.5	161.25
February,	24	173-40	201.928	19,752,597	99.	138.60
March,	26	179-50	206,450	20,194,939	90.	126.00
April,	26	198-10	230,432	22,540,858	95.5	143.70
Totals,	322	2,282-45	2,567,671	251,169,575	1,155.5	$1,704.80

Average daily consumption, 688,136 gallons. Average daily consumption for each service, 1,147 gallons.

The running expenses for the year have been:

For Salaries,	$2,018.50
" Fuel,	1,704.80
" Repairs,	404.17
" Oil, &c.,	113.95
Total,	$4,241.42

Average height of lift of water, exclusive of friction in pump and force main, . 150 feet.

Total cost of raising one million gallons into reservoir, $16.88
" " " " " " 1 foot high, 0.11.25-100
Cost of fuel for raising 1 " " into reservoir, 6.78
" " " " " " " 1 foot high, .04.52-100

The performance of the engine is satisfactory. During the month of April a duty trial of the machinery was made by the City Surveyor, the duty developed being 25,483,975 pounds raised one foot high for every hundred pounds of pine slabs used. Assuming that two and one-half pounds of the fuel equals one pound of Anthracite coal, the duty becomes 63,709,938 pounds raised one foot for each hundred pounds of coal.

The completion of the duplicate engine now in process of construction, and connection with the one now in use, will furnish means for obtaining still greater results, as well as much greater security from accidents which might endanger the water supply.

Annexed is a schedule of tools and material on hand at the pumping station.

Respectfully submitted,

DEMETRIUS TURNER,

Engineer of Pumping Machinery.

Inventory of Stock and Tools on hand at Pumping Station May 1st, 1878.

FUEL.

195 cords of Hard Wood,

632 cords Pine Slabs,

1500 lbs. Coal.

OIL.

20 gallons Cylinder,	$25.00
2 gallons Lard,	2.00
2 gallons Kerosene.	.70
Total,	$27.70

TOOLS, &c.

1 1¼ Auger,

4 small Bits,

1 Packing Hook,

6 Cold Chisels,

6 Files,

1 1-gallon Jug,

TOOLS, ETC.,—CONTINUED.

3 Air Pump Valves,
3 lbs Rubber Packing,
2 lbs Piston Packing,
3 lbs Hemp Packing,
5 lbs Rope,
10 lbs nails,
20 lbs Old Brass,
1 Steam Gauge,
4 Glass Tubes for air chamber
1 Glass Tube for boiler,
4 Springs for pump.
4 Springs for air chamber,
3 ½-inch Pet Cocks,
5 lbs. Waste,
3 2½-inch Globe Valves,
2 2-inch " "
3 1½ " " "
3 1¼ " " "
2 1 " " "
2 ¾ " " "
2 1-inch Check Valve,
2 1¼ " " "
2 ¾ " " "
1 2½ " Brass Coupling,
3 ¾ " Iron "
5 1-inch Plugs,
4 ¾ " Elbows,
1 2 " "
1 3 " "
7 2½-inch Flanges,
3 2½ " Tees,
4 2½ " Flanges,
1 12-ft. Eye Bolt,
1 bushel old Bolts,
2 2-gallon Oil Cans,
2 5 " " "
2 10 " " "
2 1 " " "
2 1-qt. " "
3 1-pt. " "
2 Squirt Cans,
2 Spittoons,
4 yards Canvas,

1 Vise,
4 Water Pails,
1 Step Ladder,
6 Chairs,
1 Dust Pan,
1 Stove Shovel,
1 Stove and Pipe,
2 Hand Lamps,
5 Wall Lamps,
1 Brass Oil Pan,
1 Stove Poker and Hook,
2 long Valve Wrenches,
1 large Socket Wrench,
4 long " Wrenches,
1 short " Wrench,
12 Spanners,
2 large Monkey Wrenches,
4 small " "
2 Door Mats,
2 long Ladders,
1 short Ladder,
25 feet of 1-inch Hose,
90 " 2½-inch "
2 Scoop Shovels,
2 long-handled Shovels,
1 common Hoe,
1 Fire Hoe,
2 Fire Hooks,
2 long Fire Hooks,
1 Flue Brush,
1 Boiler Scraper,
1 Sledge,
1 Rake,
2 Pokers,
1 long Boiler Chisel,
1 Hand Saw,
1 Pick,
1 Barrow,
1 1½-inch Hose Nozzle,
1 ¼-inch " "
1 Hatchet,
1 Lantern,
1 Brace,

GAS PIPE.

22 feet 2½-inch.
8 " ½-inch,
6 " ¼-inch,
16 feet 1½-inch,
14 " 1¾-inch,
13 " 2¾-inch.
14 feet 1-inch.

INVENTORY OF TOOLS AT SHOP.

20-inch Pipe, 2 sections,
16-inch " 5 "
12-inch " 15 "
12-inch " 8 11-feet sec.,
12-inch " 2 10-feet "
12-inch " 1 8-feet "
12-inch " 1 4-feet "
8-inch " 15 sections,
8-inch " 5 5-feet sec.,
6-inch " 49 sections,
6-inch " 2 8-feet sec.,
5-inch " 1 4-feet "
4-inch " 8 sections,
4-inch " 2 5-feet sec.,
Lot of old Wyckoff Pipe,
1 20-inch Sleeve,
1 12-inch "
2 10-inch "
2 8-inch "
8 6-inch "
6 4-inch "
4 Lowry Hydrant bases,
4 Valve Frames and Covers,
1 6-inch Plug for Iron Pipe,
5 Ludlow Hydrants and Frost Cases,
3 6-inch Elbows for Ludlow Hydrants,
1 Hydrant Frame and Cover,
1 20-inch Flange Valve,
1 6-inch Hub Valve,
1 4-inch " "
1 6-inch Valve Body,
1 16-inch " Stem,
2 14-inch " Stems,
2 12-inch " "
2 10-inch " "
2 8-inch Valve Stems,
2 6-inch " "
3 4-inch " "
1 12 x 6 T,
1 10 x 6 T,
1 Iron Lead-kettle,
1 Ladder,
1 10-inch Hydrant Extension,
3 Wood to Iron Nipples,
500 feet 2-inch Plank,
3 ¾ Ball & Fitts Piston Meters,
2 ⅝ " " " "
2 1 " " " "
1 1 " " " Rotary,
4 Meter Boxes,
1 Stove,
1 Testing Pump,
3 Bands for Wood Pipe,
20 ft. ¼-inch Chain,
2 Crow Bars,
1½ Bunches Shingles,
1 10-inch Wood Plug,
1 8-inch " "
1 6-inch " "
2 Shovels,
3 Picks,
1 Snow-shovel,
40 feet Inch-rope,
1 Portable Derrick,
35 ¾ Bolts, 6 feet long,
5 Rings for Pump Logs,
4 Ludlow Hydrant Valves,
12 Rubber Valves for Lowry Hydrant,
23 Rubber Gaskets for Lowry Hydrant,
1 Screw Stem for Lowry Hyd.

INVENTORY OF TOOLS AT SHOP.

1 Lowry Hydrant complete,
80 lbs. 20p Nails,
300 feet 2½.inch Hose,
2 Sledges,
2 Hammers,
2 Hardys,
1 Axe,
3 Lanterns,
2 Lowry Hydrant Wrenches,
4 Valve Wrenches,
2 Ludlow Hydrant Wrenches,
1 Stop Cock Box,
1 Pump,
1 Hydrant Head,
3 Hand Saws,
1 Cross Cut Saw,
1 Work Bench,
1 Vise,
5 Files,
3 Cold Chisels,
9 Calking Tools,
1 Ratchet,
1 Clamp,
6 Drills,
4 pair Gas Pipe Tongs,
1 pair Pliers,
1 Yarning Tool,
1 Stone Drill,
½ gross No. 12 Screws,
5 Valve Nuts,
2 Hydrant Rods,
2 Lowry Hydrant Valve Seats,
1 Solder Pot,
1 Lifting Hook,
1 Scraper,
1 Turn Pin,
1 Ladle,
3 Hydrant Valve Cases,
2 Glands for Ludlow Hydrant,
1 Cap for Lowry Hydrant,
1 Scythe Stone,
3 Lead Meter Connections,
1 Oil Can,
1 ½-gallon Kerosene Can,
Lot of Gas Pipe Fittings,
4 Hose Connections,
2 Paint Brushes,
1 Brace,
8 Bits,
2 Water Pails,
Lot old Bolts,
" Brass and Lead,
2 Saw Horses,
3 Post Hydrant Wrenches,
1 Stone Hammer Head,
4 Meter Connections,
1 Hand-cart,
1 pair Rubber Boots,
1 1-inch wood Corporation Cock
39 ¾ " " " "
95 ⅝ " " " "
72 ½ " " " "
10 ½ " iron " "
28 ⅝ " " " "
22 ¾ " " " "
18 1 " " " "

1 75-foot Tape Line,

City Surveyor's Report.

City Surveyor's Office,
Grand Rapids, Michigan, May 1, 1878.

To the Honorable Mayor and Common Council of the City of Grand Rapids.

Gentlemen:—I submit herewith a statement of such improvements as have been carried forward the past year under the direction of the Board of Public Works.

STREETS.

The following table shows the street improvements which have been completed, together with the cost and character of the improvement, and also the street work now under contract and uncompleted:

The total length of the streets now opened in the city is 131.82 miles, of which 66.81 miles are unimproved, and 65.01 miles improved.

The classification of the improved streets is as follows:

Graded and paved with wood,	0.15	miles
Graded and paved with wood and stone,	2.92	"
Graded and paved with stone,	1.55	"
Graded, gravelled and gutters paved,	22.69	"
Graded and gravelled,	29.49	"
Graded,	8.21	"
Total improved,	65.01	"

Street Improvements Completed May 1st, 1877 to May 1st, 1878.

NAME OF STREET.	FROM	TO	KIND OF IMPROVEMENT.	LENGTH.	COST.			CONTRACTORS.
					Construction.	Assm't Etc.	Total Cost.	
South Lafayette St....	Wealthy Ave...	Fifth Avenue...	Graded and Gravelled................	2565 ft.	$2296.00	$161.59	$2457.59	Terence McGee......
Wenham Avenue,.....	South Division	S. Lafayette......	Grad'd, Grav'led & Gutters Pav'd	1505 "	2501.00	150.84	2651.84	Utes & Livingston..
South Front St..........	West Bridge......	Pearl,...............	Graded	1856 "	2396.00	101.50	2497.50	Powers & Converse
West Bridge St.	Broadway,........	Gold.................	Grad'd, Grav'led & Gutters Pav'd	1400 "	4948.00	169.71	5117.71	P. J. Britton...........
First Avenue,............	South Division	Buchanan........	" " " "	1254 "	1870.00	155.62	2025.62	Prange & Wiseman
Caledonia St..............	Taylor..............	Plainfield Ave..	Graded	1010 "	235.00	77.80	312.80	Joel Collins,...........

STREET IMPROVEMENTS COMMENCED DURING THE YEAR AND NOT COMPLETED.

					ESTIMATED COST.			
E. Fulton St..............	Division	S. Spring,.........	Cobble Stone & Wood Block Pav.	286 ft.	$774.00	$96.00	$870.00	T. C. Brooks..........
N. Spring St..............	Monroe............	E. Fulton........	Cobble Stone & Wood Block Pav.	252 "	674.00	56.00	730.00	T. C. Brooks..........

SEWERS.

The following table shows the sewers constructed during the year:

SEWERS CONSTRUCTED FROM MAY 1, 1877, TO MAY 1, 1878.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	LENGTH.	MAN-HOLES.	CATCH BASINS.	TOTAL COST.	NAME OF CONTRACTOR.
E. Fulton Street	N. Ionia to point 75 feet W. of Division	½-inch Pipe	647 ft.	2	1	$764.40	Joel Collins
Sibley Street Sewer and Ditch	Sewer from Jefferson Street to W. line of Straight Street, and open ditch from Straight Street to W. city Limits	24 x 36 inch Brick	10 "	4	16	$3167.20	L. Snyder
		22 x 33 inch Brick	321 "				
		16 x 24 inch Brick	330 "				
		15-inch Pipe	328 "				
		Open Ditch	2597 "				
S. Lafayette	Wenham Avenue to Logan Street	16 x 24 Brick	69 "	Built in connection with S. Lafayette St. Improvm't.			
		12-inch Pipe	51 "				

The total length of the sewers now in use in the city, so far as can be ascertained, is 15.97 miles.

The following table exhibits the size and length of each description of sewer:

BRICK.		FIRE CLAY PIPE.		CEMENT PIPE.		WOOD.	
SIZE IN INCHES.	LENGTH IN FEET.	SIZE.	LENGTH.	SIZE.	LENGTH.	SIZE.	LENGTH.
10'-4"x6'-2"	358	24	358	18	96	8'x4'	3981
10'x6'	106	22	367	12	1701	18"x24"	1635
6'	2246	20	1173	9	513	18 x 18	850
5'x6'	1164	18	6780	8	370	12 x 18	834
4'x5'	2889	15	7178			12 x 12	974
40"x60"	712	12	17212				
36"x54"	86	9	2310				
36"x48"	5117						
30"x45"	843						
24 x 36	3337						
22 x 33	893						
24 x 30	1544						
20 x 30	3614						
20 x 24	3551						
18 x 27	947						
18 x 24	6411						
16 x 24	3541						
18	1234						
Total feet.........	38043		35378		2680		8274
Total miles......	7.20		6.70		0.50		1.57

Total of all kinds, 15.97 miles.

The increase of population, and consequent increase of sewage delivered into the sewerage system, render more apparent the necessity of guarding against the evils resulting from the passage of sewer gas through imperfect house connections.

Such connections are often made in the most improper manner, either from motives of economy or lack of knowledge, and often sickness and even death result in consequence.

The remedy lies in a well ventilated sewerage system, and properly constructed house connections.

These should always be put in under such regulations and restrictions imposed by municipal authority as will insure the occupants of the building from this ever present danger.

N. B.—Since the above was written, rules and regulations have been adopted by the Board of Public Works in reference to tapping sewers and laying house drains, the same to be done by licensed drain layers.

CATCH BASINS.

Three catch basins have been constructed at the junction of Jefferson Avenue and Washington Street, and connections made with the Fulton and Washington street sewer. These connections are provided with pipe traps which prevent the annoyance and danger caused by the escape of sewer air. The cost of this work was $116.04.

BELL TOWER.

A bell tower has been constructed on the city lot, corner of Pearl and Ottawa streets. It is 21 feet 6 inches square at the base and 14 feet square at the bell deck, which is about 68 feet above the Ottawa street pavement. The tower is an open frame structure, built of made beams and covered with a tin roof.

The cost was $541.10.

FIRST WARD ENGINE HOUSE.

An Engine House has been constructed on the corner of Summit street and Grandville Avenue in the First ward, the plans for which were made for the City Surveyor by Robinson & Barnaby, architects of this city. The building is of white brick with stone and red brick trimmings.

An ornamented tower rises from one corner of the front, adding much to the fine appearance of the structure.

The building is 30 x 65 feet on the ground, has stalls for three horses, ample room for fire apparatus, and large hall and hay-loft room on second floor.

The cost of construction was $2830.48, not including superintendence.

Owing to lack of funds, the plastering of the building was not embraced in the contract for construction. Shortly before the completion of the contract a further appropriation was made by the Common Council for the plastering and painting, following which a contract has been awarded for the work.

The cost is estimated at $174.50.

FOURTH WARD ENGINE HOUSE-

An Engine House has been constructed on the corner of Bronson and Kent streets. in the Fourth ward, the designs for which were prepared by Robinson & Barnaby, architects.

The building is 50 by 76 feet on the ground, two stories in height, with bell tower on corner, the finial of which is 93 feet from the ground. White brick were used in construction, with Berea stone and red brick trimmings.

The ground floor has a large office, ample room for fire apparatus, and stalls for six horses. The second floor has hayloft and battery room in the rear, three large sleeping rooms on the sides, and foreman's room and reading room in front. Bath room and water closets are also provided. The building is not entirely completed.

The estimated cost is $5000.

A portion of the old Kent street engine house roof has been covered with gravel roofing and connected with the new building.

The cost of this work was $107.00.

BOILER.

A new boiler has been placed in the boiler room at the pumping station.

It is of the retuan tubular pattern, 18 feet in length, with 90 4-inch tubes 16 feet long. The diameter of the shell is 78 inches. It is built of Otis steel plate and double rivetted throughout.

The cost was $3360.50.

The following is the cost of the improvements completed during the year;

Street improvements, - - - - -	$15,063.06
Sewerage, - - - - - - - - - -	4,047.64
Buildings, including superintendence etc., -	3 956.84
Boiler, - - - - - - - - - -	3,360.50
Total,	$26,427.54
Payments on incomplete work, - - - -	3,643.82
Total,	$30,071.36
Paid prior to May 1, 1877, - - - - -	7,642.96
Paid during year, - - - - - -	$22,428.40

OFFICE AND FIELD WORK.

A large amount of office and field work of an important character has been completed during the year.

Carefully executed maps of nearly all the wards have been made to replace the old ones which are worn out.

A large map showing the pipe distribution connected with the water works, with the kind and size of mains, and location of stop valves and hydrants, has been prepared and placed in the office of the Board of Public Works.

A large map has also been prepared of the sewerage system so far as extended. showing the kind and sizes of the sewers built.

Data are being collected for the preparation of a complete topographical map of the city. Upon this map will be projected the plans for the future sewerage extension.

Respectfully submitted,

A. C. SEKELL, City Surveyor.

ANNUAL REPORT

—OF THE—

BOARD OF PUBLIC WORKS

—AND—

CITY SURVEYOR,

—OF THE—

City of Grand Rapids,

For the Year ending April 30, 1879.

GRAND RAPIDS.
EAGLE JOB ROOMS—W. C. DENNIS & CO.
1879

REPORT

OF THE

BOARD OF PUBLIC WORKS,

TO THE

Common Council of the City of Grand Rapids,

Transmitting the Reports of the

SUPERINTENDENT, COLLECTOR AND ENGINEER

OF THE WATER WORKS,

For the Fiscal Year Ending April 30th, 1879.

ALSO THE

ANNUAL REPORT OF THE CITY SURVEYOR.

GRAND RAPIDS.
EAGLE JOB ROOMS—W. C. DENNIS & CO.
1879.

Report of the Board.

GRAND RAPIDS, May 1st, 1879.

To the Honorable the Mayor and Common Council of the City of Grand Rapids:—GENTLEMEN:

The Board of Public Works have the honor to submit the following Annual Report for the year ending April 30, 1879.

Your attention is respectfully invited to the accompanying Reports of the Superintendent, Collector and Engineer, for full and complete information regarding the present condition of our water works system, and for detailed statements of the receipts and expenditures during the year, with the cost of the works and other matters of special interest.

The report of the Superintendent shows the excellent condition of the works under his charge, and the careful and economical manner with which the repairs and inspections have been made. The fire hydrants, one of the most important branches of the water works were never in better condition, and in no case have they failed to supply the demands of the fire department. This condition of the works is in a great measure due to the vigilence and industry of the Superintendent whom the Board consider to be peculiarly well fitted to fill the duties of his office.

The report of the Collector and Clerk furnishes a full and comprehensive statement of the receipts and expenditures of the department for the past year, and also for the whole time the works have been in operation, together with the entire cost of the works to date. The income of the works for the past year has been $7,496 02 more than the cost of maintenance and salaries, while the expenditures were $943 17 less than the year previous.

The satisfactory condition of this department gives evidence of the ability and faithfulness of the Collector and Clerk, he having fully met the expectations of the Board in the discharge of his duties.

The report of the Engineer in charge of the Pumping Machinery exhibits fully the operations of this department. While the total amount of water pumped was slightly over 30 per cent in excess of the previous year, the total cost of pumping was increased less than 4 per cent.

This increased consumption was owing principally to the fact that large quantities of water were used during the summer months for flushing the main lines of pipe and for washing sewers and streets. The total cost of pumping each million gallons will compare very favorably with the cost in other cities, being considerably less than during the previous year, and it is believed that the coming year will witness a still further reduction. Our pumping facilities are now double those of former years ; the new duplicate pumping machinery being substantially completed and ready for service. The consequent immunity from accident now provided, together with the very satisfactory management of Mr. Turner the Engineer and his assistants enable us to regard this branch of our water works with especial satisfaction.

The Board deem it their duty to again, as in former reports, invite the attention of your honorable body to the propriety of making annual payments to the water works income fund for water taken for public use.

Large quantities of water are annually used for washing streets, for flushing sewers and for the extinguishment of fires, for which the Water Works Income Fund receive no credit. While it is true that the Board take pleasure in being able to meet readily these demands for water for municipal use, it is also true that we deem it a mistake that thus far the income fund has received no acknowledgment for the service. That this would in no way affect the city treasury, is well understood, while being a merited recognition of the value of the water used.

For a detailed statement of the street improvements, sewerage and other public work conducted by the Board during the year your attention is respectfully invited to the Annual Report of the City Surveyor.

More than double the work has been done than during the previous year, and it is believed that the same is of a substantial and durable character especially in the matter of paving and graveling of roadbeds. We have required yellow cedar blocks for wood paving in all cases and believe the use of pine should be permanently abandoned. We have also in all cases required screened gravel for our roadbeds and such complete rolling of the same as the character of the work demanded. That our graveled streets do not pack as easily and speedily as heretofore, we believe will in the end be found to be a favorable fact in securing their solidity and permanence.

Our labors in connection with public improvements have been greatly facilitated by the City Surveyor. To this officer we are indebted.

The total expense of the five members of the Board including salaries for the past year has been $268 50.

It gives us pleasure to present so satisfactory an account of the work for the past year, and to report the Department under our care in good condition throughout.

Respectfully submitted,

JAMES MILLER,
F. B. DAY,
JOHN S. FARR,
THOMAS FARMER,
WM. P. INNES,
Board of Public Works.

SUPERINTENDENT'S REPORT.

OFFICE OF THE BOARD OF PUBLIC WORKS,

May 1st, 1879.

To the Honorable the Board of Public Works :

GENTLEMEN :—In accordance with the custom of former years I have the honor to present the annual report of the Grand Rapids Water Works for the year ending April 30th, 1879.

There have been no extensions of the water mains, owing to the fact that there has been no money appropriated for such a purpose, but in a number of cases, private individuals owning property fronting on a street not provided with a main, have laid pipes from one to two inches in size a distance of from 300 to 1200 feet in order to derive the benefits of the water works. In one case such a pipe is now supplying five houses with an immediate prospect of two more.

There have been no serious breaks in the mains the past year, the leaks being of a minor nature caused in a majority of cases by the settlement of the ground.

The iron pipes have given but little trouble during the year but two leaks having occured, one of which was caused by the lead being blown out of the joint, the other a crack in a twelve inch pipe at the spigot end and repaired by putting on an iron band, thus obviating the necessity of putting in a new pipe.

The total expense for repairs on iron pipe has been $2 90. This does not include the expense of lowering 38 feet of pipe made necessary by the grading of Sheldon Street.

The "Wyckoff Patent Pipe" is also in good condition. In uncovering the pipe for tapping or repairing, I find no traces of rust on the iron bands, and the tar coating is in a majority of cases very firm. The trouble with this pipe seems to be in the joints, sixteen of which were repaired during the year. The repairing is done by calking the joints with oakum and cement. Six knots also blew out which were repaired by plugging. The expense of maintaining this kind of pipe is borne by the contractors, Farrington & Branch.

The pump logs are doing very good service, but one having burst during the year. The number of other leaks have been eleven—eight joints, three knot holes.

The supply pipe is in as good condition as last year.

The hydrants have all been examined several times during the year; new springs in the waste valves have been substituted for the old ones, making them much more reliable. A number of new valves have been put in to replace those injured by stones &c. In no case has the Fire Department required the use of a hydrant but what it was found to be in good working order. The large number of streets graded last year necessitated the raising of a number of hydrants thus making the expense of maintaining them somewhat larger than it would otherwise have been.

The valves are all in good shape and are all open. Once during the year the water was shut off the entire west side for three hours in order to repair a twelve inch valve at eighth street ; the stem of the valve being so badly cut that it could not be closed. Outside of a few leaks in the stuffing boxes, no other trouble of any account has been had with the valves.

The reservoir and settling basin are in good condition and the expense of maintaining them $4 45 has been very small and taking their first cost into consideration, no branch of the Water Works makes a better exhibit.

There have been six meters purchased the past year making a total of 94 meters owned by the city, as follows:

82 Ball & Fitts, Piston.
5 " " Rotary.
7 Worthington,

A two inch meter, the largest one in use here, has been placed on the 2 inch service supplying the G. R. & I. R. R. Co. There has been some trouble occasioned by meters breaking down although not as much as in former years.

The number of new services put in has been 89. From present indications a much larger number will be put in the present year.

The regrading of South Division Street made it necessary to lower about 800 feet of 12 inch Wyckoff pipe between Maple Street and Wealthy Avenue. This work was successfully accomplished without accident of any kind and only requiring the shutting off of the water for three days. The total expense of this work was $132 00.

The increased consumption made manifest by the Engineer's report together with the prospect of a continued increase the coming years, make apparent the necessity of immediate steps looking toward an increased supply of water.

The total length of pipe now laid is 22–28 miles; number of hydrants 234 and number of valves 132.

In conclusion I desire to return my thanks to the several members of the Board for their kindness and courtesy extended to me the past year.

Respectfully submitted.

THOMAS FARMER, Jr.,
Sup't W. W.

COLLECTOR'S REPORT.

OFFICE OF THE BOARD OF PUBLIC WORKS,
May 1st, 1879.

To the Honorable Board of Public Works of the City of Grand Rapids :

GENTLEMEN :—I respectfully present the following report for the year ending April 30th, 1879.

The number of services on the 1st of May, 1878, for which permits were issued, were,	690
Taps granted without permits,	15
Private mains connected with works,	15
Total,	720
Number of services put in the past year, for which permits were issued,	83
Taps granted without permits,	5
Private mains connected with works,	1
Total number of connections on May 1st, 1879,	809
Number of services now cut off,	69
Number of services now open,	740

The receipts for the year have been somewhat less than during the year previous. This is owing entirely to the fact that most of the collections for the previous year really covered about fifteen months use of water. This was due to a change in the manner of assessing and collecting rates on sprinklers and fountains, which added greatly to the legitimate receipts of that year, otherwise the past years receipts would largely exceed those of the year previous.

The receipts at this office for the year have been as follows:

From Water Rates, - - -	$13,016 74
" " Permits, - - -	545 75
" Farrington & Branch for repairs, - -	172 09
Total income from Water works, - -	$13,734 58
There has also been received from sewer permits,	51 00
Total receipts for the year, - -	$13,785 58
Cash on hand May 1st, 1878, - -	209 67
	$13,995 25

Deposits haye been made with the City Treasurer during the year as follows:

To the credit of Water Works Income Fund,	$13,738 88
" " 1st District-sewer fund, -	45 00
" ' 2d " " " - -	6 00
Total deposits during the year, - -	$13,789 88
Cash on hand to balance, - - -	205,37
	$13,995 25

Receipts previous to May 1st, 1878 :

From Water Rates,	$31,430 49
“ “ Permits,	3,461,23
“ Sewer, “	231 00
“ Farrington & Branch, repairs,	131 91
“ Carter & Sullivan, (ac't iron pipe,)	97 62
“ G. R. Gas Co., four inch valve,	30 00
“ G. R. & I. R. R. Co. pipe,	50 70
“ H. E. Thompson, pipe,	44 27
Total,	$35,477 22
Receipts for the past year,	13,785 58
Total receipts to date,	$49,262 80

Deposits made previous to May 1st 1878 :

To the credit of Water Works Income Fund,	$34,960 65
“ “ “ “ “ Fund,	264 90
“ “ “ 1st District Sewer Fund,	36 00
“ “ “ 2nd “ “ “	6 00
Total,	$35,267 55
Deposits made the past year,	13,789 88
Cash on hand to balance,	205 37
Total,	$49,262 80

STATEMENT OF EXPENDITURES

May 1st, 1878 to May 1st, 1879.

CONSTRUCTION OF WATER WORKS.

1. Pipe System.

Lowering pipe in South Division-st.,	$159 79	
" " " Sheldon-st., -	11 05	$ 170 84

2. Pumping House and Grounds.

Building Foundation, - -	$47 70	
Sewer Pipe, - - -	13 80	
Replacing Floor, - - -	15 00	
Filling Grounds, - -	21 00	97 50

3. Pumping Machinery.

Repairs to old Worthington Pump, -	25 00

4. Duplicate Pumping Machinery.

Construction, - - - - -	10,500 00

5. Meters.

6 new meters, - - - - -	166 32

6. Miscellaneous.

Printing and Telegraphing, - -	5 10

Total paid on construction, -	$ 10,964 76
Paid previous to May 1st, 1878, -	390,624 83
Total paid for construction to date, - -	401,589 59

MAINTENANCE AND OPERATION OF WATER WORKS.

1. Pumping.

Salary, Engineer,	$ 750 00
" Assistant Engineer,	720 00
" Fireman,	572 75
Fuel,	1,684 55
Repairs to Pumping Machinery,	55 97
" Boiler Arches,	7 60
Supplies, (oils, packing &c.)	223 88
	$4,014 75

2. Office & Collecting.

Salary, Collector,	$540 00
Printing and Advertising,	19 25
Stamps and Stationery,	36 90
Freight, Telegraph &c.,	41 17
	$637 32

3. Superintendence and Repairs.

Salary, Superintendent,	$897 00

REPAIRS.

1. Iron Pipe.

Labor,	$2 50	
Material,	40	2 90

2. Wyckoff Pipe.

Labor,	$116 60	
Material,	28 77	145 37

3. Pump Logs.

Labor,		14 45

4. Supply Pipe.

Labor,		5 00

5. Valves.

Labor.		$11 73

6. Hydrants.

Labor,	$73 85	
Material,	77 64	151 49

7. Meters.

Labor,	$37 03	
Material,	21 14	58 17

8. Reservoir.

Material,		2 30

9. Settling Basin.

Labor,		2 15

10. Supply Creeks.

Labor, watching creek,	$93 00	
Material,	3 06	96 06

11. Service Connections.

Labor,	$17 37	
Material,	67	18 03

12. Supplies, &c.

Tools,	$ 56 52	
Shut off boxes,	105 59	
Blowing off,	19 73	181 84
		$1,586 49

RECAPITULATION.

Pumping, - - - - -	$4,014	75
Office and Collecting, - - - -	637	32
Superintendence and Repairs, - -	1,586	49
Total paid for maintenance snd operation,	$ 6,238	56
Paid previous to May 1st, 1878,	33,785	79
Total paid to date,	$40,024	35
Income for the year, - - - -	$13,734	58
Cost of maintenance and operation, -	6,238	56
Excess of receipts over expenditures, -	$7,496	02
Cost of operation for the year, ending May 1st, 1878, - - -	$7,181	73
Cost for the past year, - - -	6,238	56
Decrease in expenditures,	$943	17

I extend to the President and Members of the Board, my acknowledgment of courtesies received during the year.

Respectfully submitted,

FRED A. TWAMLEY,
Collector.

ENGINEER'S REPORT.

GRAND RAPIDS, MICH., May 1, 1879.

To the Honorable, the Board of Public Works of the City of of Grand Rapids:

GENTLEMEN:—I have the honor to submit herewith, my annual report of the work done by the pumping engine, for the year ending April 30, 1879.

The engine has been running on 342 days, making a total of time run 2779 hours and 50 minutes, against 322 days or 2282 hours and 45 minutes run the year previous.

The total number of revolutions made was 3,347,105, against 2,567,671 the previous year.

The new duplicate pumping machinery is substantially completed and ready for service.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped and amount of wood burned. The estimated quantity of water pumped per revolution is 97.82 gallons.

MONTH.	Days Pump'd	Time Run. H. M.	No. of Revolutions	Gallons Water Pumped.	Cords of wood used.	Cost of wood used.
May,...	27	181—15	217,693	21,294,729	118	$165 20
June,...	27	211—10	238,305	23,810,995	101	141 40
July,...	31	287—20	326,874	31,974,814	134.5	188 40
August,...	31	272—10	318,415	31.147,355	138	193 20
September,...	28	264—25	311,753	30,495,678	135	189 00
October,...	27	232—10	279,013	27,293,051	124	173 60
November,...	26	208—00	252,993	24,747,775	119	166 60
December,...	26	209—10	260,596	25,491,500	126	176 40
January,...	31	254—10	315,477	30,859,959	142	198 80
February,...	28	221—40	278,758	27,268,107	129	180 60
March,...	31	229—10	282,857	27,669,071	104	145 60
April,...	29	209—10	264,370	25,860,673	87	121 80
Total,...	342	2779—50	3,347,105	327,413,707	1,457.5	$2,040 60

Average daily consumption, 897,024 gallons, against a daily average the year previous of 688,136 gallons, or an increase of over 30 per cent.

Approximate daily consumption for each service, 1,281 gallons, against 1,147 gallons the previous year.

The running expenses for the year have been,

For Salaries,	$2,042 75
" Fuel,	2,040 60
" Repairs,	138 98
" Oil, Packing, &c.,	179 14
Total,	$4,401 47

Average lift of water not including friction in pump and force main, - - 150 feet.

Total cost of raising one mill. gal'ns into reservoir,	$13 44
" " " " " " " 1 foot,	$0.08 96-100
" " " fuel for raising 1 mill. gal'ns into res'v'r,	$6 23
" " " " " " " " 1 foot,	$0.04 15-100

Respectfully submitted,

DEMETRIUS TURNER,

Engineer of pumping machinery.

Inventory of stock on hand at pumping station May 1, 1879.

FUEL.

120½ cords of hard wood,

274½ cords of pine slabs,

1000 lbs. of stove coal.

OIL.

42½ gallons of cylinder oil @ 90c. - -	$38 25
1½ gallons of lard oil @ $1 00, - - -	1 50
3 gallons kerosene oil @ 30c. - -	90
Total,	$40 65

CITY SURVEYOR'S REPORT.

CITY SURVEYOR' OFFICE,

Grand Rapids, Michigan, May 1, 1879.

To the Honorable Mayor and Common Council of the City of Grand Rapids:

GENTLEMEN ;—I have the honor to submit the following report of the public improvements, made under direction of the Board of Public Works, for the year ending April 30, 1879.

STREETS.

The following table exhibits the several street improvements completed during the year, together with the character of the work and the cost, and also the several street improvements now under contract.

Street Improvements Completed during year ending April 30, 1879.

NAME OF STREET.	FROM.	TO	KIND OF IMPROVEMENT.	LENGTH	COST.				CONTRACTORS.
					Construction.	Assm't &c	Total.	Per foot	
E Fulton................	Division............	Spring............	Cobble Stone & Wood blk Pavem,t	286 ft.	$801 32	$84 20	$885 52	$3 69	T. O. Brooks..........
N. Spring............	Monroe............	E. Fulton.........	" " " " "	252 "	674 64	75 80	749 94	2 97	T. C. Brooks..........
N. & S. Division.....	Monroe.....	Wealthy Aven'e	" " " " "	2802 "	6427 96	379 88	6807 84	2 43	T. C. Brooks..........
Kent	Lyon	Bronson	" " " " "	484 "	1059 55	89 75	1149 80	2 37	L. D. Leonard.........
Pearl	Canal.........	Pearl St. bridge	" " " " "	426 "	1029 39	102 25	1131 64	2 65	Thomas Martin......
Sheldon	E Fulton..........	Blakeley Ave...	Graded, Graveled & Gutters Paved	3605 "	6843 99	409 62	6758 61	1 88	Prange & Wiseman

STREET IMPROVEMENTS COMMENCED DURING THE YEAR AND NOT COMPLETED.

					ESTIMATED COST.				
Plainfield Ave........	Taylor..	E Leonard........	Graded, Graveled & Gutters Paved	647 ft.	$944 90	$205 10	$1150 00	....	L. D. Leonard........
Taylor	Coldbrook........	N W line Plainfield Ave.......	" " " "	237 "	500 00	100 00	600 00	....	L. D. Leonard ....
Street at Settling Basin	Clancy.............	Coldbrook........	Graded and Graveled.....................	600 "	....	....	397 00	....	L. D. Leonard ....

The total length of the streets now opened in the city is 132.16 miles, of which there are:

Graded and paved with wood, - - - -	0.07 miles
Graded and paved with wood and stone, -	3.72 "
Graded and paved with stone, - - - -	1.55 "
Graded, graveled and gutters paved, - -	22.84 "
Graded and graveled, - - - - -	29.35 "
Graded, - - - - - - - -	7.48 "
Unimproved, - - - - - -	67.15 "
Total, - - - - - -	132.16 "

SEWERS.

Including the sewerage now in process of construction the total length of the sewerage system is 16 5218-5280 miles, of which there are

Brick sewers, - - - - -	7 4863-5280 miles
Glazed pipe sewers, - - - -	6 5220-5280 "
Cement pipe sewers, - - - -	0 2559-5280 "
Wood sewers, - - - - -	1 3136-5280 "
Total, - - - - -	16 5218-5280

The following table shows the sewers constructed during the year, together with their location, cost, &c., and also the sewerage commenced during the year and not yet completed:

Sewers Constructed during year ending April 30, 1879.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man Holes.	Catch Basins.	Length	COST.			CONTRACTOR.
						Construction.	Assm't &c	Total.	
Barclay....................	200 feet S. of Lyon St. to Fountain St..............	12 in. glazed pipe	1	0	504 ft.	$310 00	$51 50	$361 50	Joel Collins...........
S. Division..............	25 feet N. of Wealthy Ave, to Maple St............	12 " " "	1	8	827 "	687 00	68 75	750 75	L. Schneider,.........
Plainfield Ave........	Carrier St. to Coldbrook Creek......................	15 " " " 18 in. brick.........	2	6	327 " 367 "	706 50	240 99	947 49	P. J. Britton ....
Plainfield Ave. and Taylor St............	75 feet S. of Coldbrook Creek to Coldbrook St.	12 in. glazed pipe	1	2	445 "	437 40	92 63	530 03	Leonard Snyder.....

SEWERS COMMENCED DURING THE YEAR AND NOT COMPLETED.

						ESTIMATED COST.			
Prescott, &c............	From 20 feet E. of S. Ionia St., E. in Prescott St. to S. Division St., thence S. to Blakeley Ave., thence E. to Center St., thence S. to alley, thence E. to alley, thence S. to Pleasant St., thence E. to S. Lafayette St.	16x24 in. Brick...... 18x27 " " ...... 20x30 " " ...... 22x33 " " ...... 36x54 " "	8	8	307 ft. 300 " 827 " 964 " 558 "			$4500 00	Utes & Livingston,

FOURTH WARD ENGINE HOUSE.

The Fourth Ward Engine House was completed early in the year, the final account being allowed by the Board on May 4, 1878, at $1247.30.

The total amount allowed by the Board upon the contract for its construction was $4891.12. A description of the building may be found in the last report of the Board.

FIRST WARD ENGINE HOUSE.

PLASTERING AND PAINTING.

The First Ward Engine House has been plastered and painted as ordered by the Common Council, by resolution adopted March 4, 1878. The work was done by Peale & Miller, and the cost was $188.42.

PARK WALKS.

Gravel walks have been constructed in the Fulton street park, by Utes & Livingston, at a cost of $160.00.

DUPLICATE PUMPING ENGINE.

A contract for the construction of duplicate pumping machinery was awarded to R. E. Butterworth, on April 30, 1878, for the sum of $11,200.00. The work is now substantially completed and ready for use.

The engine will be able to deliver 3,000,000 gallons into the reservoir in 24 hours, and it is believed that its use will permit considerable saving in the annual expenditures for fuel, as well as guard against any accident that might occur by reason of the failure of any part of the engine now in use, which has been running since June, 1875.

There has been paid on account of construction the sum of $10,500.00.

The following is the cost of the several improvements which have been completed during the year, including incidental expenses, but not including cost of superintendence on buildings:

Street improvements, - - - - -	$17,477 85
Sewerage, - - - - - - - -	2,589 77
Buildings, except superintendence, etc., -	5,079 54
Park walks, - - - - - - - -	160 00
Total cost of work completed, - -	$25,307 16
Payments by Board on incomplete work, -	14,713 98
Total, - - - - - -	$40,021 14
Payments by Board prior to May 1, 1878, -	3,643 82
Payments by Board during year, including incidentals on completed work paid by Council,	$36,377 32

Annexed is a list of the several sewers in the city, including the sewerage now in process of construction, showing their location, size, kind of material, length, and date of construction.

Respectfully submitted,

A. C. SEKELL,
City Surveyor.

EAST SIDE SEWERAGE MAY 1, 1879.

STREET.	LOCATION,	MATERIAL.	Size in Inches.	Length.	When built.
Barclay	From 200 feet south of Lyon street south in center of Barclay St. to Fountain St. thence curve west to sewer in Fountain St	Glazed Pipe	12	504	1878
Bartlett	From east line of Summit St. east in center of Bartlett St. to sewer in S. Ionia St. at north line of Bartlett St	Glazed Pipe	12	556	1875
		Glazed Pipe	15	290	1875
Blakeley Ave	From west line of Center St. west in center of Blakeley Ave. to S. Division St, thence on curve to north line of Blakeley Ave. at center of S. Division St	Brick	22x33	467	1878
Bostwick	From point 423 ft. north of Fountain St. south in center of Bostwick St. to sewer in Fountain St.	Brick	20x24	456	1866
Bridge E.	From east line of Clinton St. west in center of E. Bridge St. to sewer in Kent alley	Glazed Pipe	15	587	1875
		Brick	18x24	539	1865
		Brick	36x48	110	1865
Bridge E.	From center of Canal St. east in center of E. Bridge St. to sewer in Kent Alley	Glazed Pipe	18	168	1876
Bronson	From west line alley east of N. Division, west in center of Bronson St. to point 23 ft. east of Kent alley, thence curve south to sewer in Kent alley	Glazed Pipe	12	473	1873
		Glazed Pipe	15	575	1873
		Glazed Pipe	18	129	1873
Calder	From near center of Island St. north in east gutter of Calder St. to sewer in E. Fulton St	Brick	60x72	334	1867
Canal	From center of Newberry St. on east line of Canal St. south on curve to east gutter of Canal St., thence south to point 50 ft. north of Hastings St., thence west to river	Wood	36x48	1794	63-4
Canal	From center of Hastings St. at east line of Canal St. north on curve to east gutter of Canal St., thence north 50 feet	Brick	20x24	89	
Center	From east line of Center St. at center of alley south of Blakeley ave thence north on curve to center of Center St., thence north to south line of Blakeley Ave., thence west on curve to center of Blakeley Ave. at west line of Center St	Brick	20x30	50	1878
		Brick	22x33	147	1878
Cherry	From west line of S. Division St. west in Cherry St. to S. Spring St., thence on curve north to sewer in S. Spring St	Glazed Pipe	12	318	1871
Cherry	From west line of S. Union St. near center of Cherry St., west to Lagrave St., thence on curve north to sewer in Lagrave Street at north line of Cherry St	Glazed Pipe	12	338	1875
		Glazed Pipe	15	325	1875
		Glazed Pipe	18	962	1875
		Glazed Pipe	20	357	1875
		Glazed Pipe	22	367	1875
		Glazed Pipe	24	292	1875
		Brick	24x36	305	1875
Coldbrook	From point 200 feet east of Taylor Street, west on line 5 feet south of center of Coldbrook St. to river	Glazed Pipe	12	570	1876
		Glazed Pipe	15	279	1876
		Glazed Pipe	18	273	1876

STREET.	LOCATION.	MATERIAL.	Size in Inches.	Length.	When Built.
Division N.......	From 40 feet south of Bronson St, south in center of N. Division St. to Lyon street, thence on curve west to sewer in Lyon street........	Glazed Pipe	12	498	1874
Division N.......	From north line of Pearl St. north in center of N. Division street to Lyon street, thence on curve west to sewer in Lyon street..................	Glazed Pipe	12	318	1874
Division N.......	From south line of Pearl St. south in center N Division St. to Fountain street, thence west on curve to sewer in Fountain St..............	Glazed Pipe	12	321	1874
Division N.......	From point 40 feet north of Monroe St. north in center of N. Division St. to Fountain St., thence west on curve to sewer in Fountain St	Glazed Pipe Glazed Pipe	12 15	182 378	1874 1874
Division S........	From north line of Fifth Ave. north in center of S. Division street to south line of Prescott St, thence west on curve to center of Prescott st at west line of S Division st	Glazed Pipe Brick........... Brick...........	18 18 22x33	1564 45 350	1871 1878 1878
Division S........	From point 25 ft. north of Wealthy Ave. north in S. Division street to Cherry St., thence west on curve to center of Cherry St. at west line of S Division St...........................	Glazed Pipe Glazed Pipe	12 12	491 827	1871 1878
Division S........	See Wenham Avenue sewer...........				
Division S........	From point 25 feet north of Cherry St. north in center of S. Division St. to south line of Island St, thence west on curve to sewer in Island street at west gutter of S. Division St.....	Glazed Pipe	15	869	1872
Erie,..................	From near Southeast corner of Canal and Bronson streets north in east gutter of Canal St. to north gutter of Bronson St., thence across Canal St. to center of Erie St, at west line of Canal Street, thence west to tail race...............	Glazed Pipe	12	297	1874
Fountain	From point 200 feet east of N. College Ave west in center of Fountain St. to east line of Ottawa St..	Glazed Pipe Brick........... Brick........... Brick...........	12 18 24x30 24x36	1154 1234 786 589	1876 1876 1867 1874
Fulton, E..........	From east line of Lafayette St. west in center of E. Fulton St. to W. Park Place, thence on curve to north line of E. Fulton Street at north gutter of Monroe St...........	Brick........... Glazed Pipe Glazed Pipe	20x24 18 20	656 278 528	1866 1875 1875
Fulton, E..........	From point 75 ft. west of Division St. west in E. Fulton St. to west line of Waterloo St....................	Glazed Pipe Glazed Pipe Brick..........	12 18 60x72	647 482 390	1877 1872 66-67
Goodrich	From east line of Summit St. east in center of Goodrich Street to S. Ionia St., thence north on curve to sewer in S. Ionia St........	Glazed Pipe Glazed Pipe	12 15	551 290	1875 1875
Hastings...........	From east line N. Ionia St. west in center of Hastings St. to east line of Canal St................................	Brick...........	20x24	865	1867
Ionia, N............	From point 290 feet north of Walbridge St. south in center of N. Ionia St. to north line of Wal bridge St, thence west on curve to Walbridge St. sewer at a point 50 feet west of N. Ionia St...........	Cement Pipe	8	370	1872

STREET.	LOCATION.	MATERIAL.	Size in Inches.	Length.	When Built.
Ionia, N	From north line of Fountain St north in east gutter of N Ionia St to Lyon St, thence north in center of N Ionia st to sewer in Bronson st	Wood	24x30	583	1863
		Wood	24x30	333	1865
		Wood	36x36	264	1860
Ionia, N	From point 75 ft south of Monroe st southwesterly in center of S Ionia st to E Fulton st, thence west on curve to sewer in E Fulton st	Glazed Pipe	15	500	1872
Ionia, S	From center of Prescott st, at east line of S Ionia st, north on curve to center of S Ionia st, thence north in center of S Ionia st to Williams st, thence east on curve to center of Williams st at east line of S Ionia st	Brick	40x60	712	1875
		Brick	40x60	999	1875
Island	From southwest corner of Island and Sheldon sts, westerly to center of Island st at west line of S Spring st, thence west in center of Island st to sewer in Calder st	Brick	36x46	955	67-68
		Brick	60x72	510	67-68
Jefferson ave	From south line of E Fulton st south in center of Jefferson ave to sewer near north line of Washington st	Brick	20x24	548	1866
Jefferson ave	From 350 ft north of Cherry st south in center of Jefferson ave to Cherry st, thence west on curve to sewer in Cherry st	Glazed Pipe	12	403	1875
Jefferson ave	From 150 ft north of Blakeley ave north in center of Jefferson ave to sewer in Wealthy ave	Wood	18x18	850	1867
Kent	From south line of Mason st south in center of Kent street to Newberry st, thence west on curve to sewer in Newberry st	Glazed Pipe	12	538	1874
Lafayette, S	From 50 ft south of E. Fulton st south in center of S Lafayette st to sewer in Washington st	Brick	18x24	579	1868
Lafayette, S	From center of Logan st at east line of S Lafayette st north on curve to center of S Lafayette st, thence north and west on curve to center of Wenham ave at west line of S Lafayette st	Glazed Pipe	12	51	1877
		Brick	16x24	69	1877
Lagrave	From center of Maple st at west line of Lagrave st north on curve to center of Lagrave st, thence north in Lagrave st to sewer between Island and Oakes sts	Glazed Pipe	12	515	1873
		Brick	24x36	720	1878
Leonard, E	From east line of Canal st west in south gutter of Leonard st to river	Glazed Pipe	18	206	1876
Luce	From Cherry st north in center of Luce st to sewer in Washington st	Brick	24x30	723	1869
Lyon	From center of Ransom st west in center of Lyon st to tail race	Brick	20x30	789	1870
		Brick	24x36	992	1870
		Brick	36x48	472	65-68
Maple	From 25 feet east of Sheldon st east in center of Maple st to west line of Lagrave st	Glazed Pipe	12	243	1873

STREET.	LOCATION.	MATERIAL.	Size in Inches.	Length.	When Built.
Monroe	From north line of E Fulton st northwesterly near northeast gutter of Monroe st to sewer in Pearl st at east line of Canal st	Glazed Pipe	20	15	1875
		Brick	20	263	1876
		Brick	36x48	1480	1869
Newberry	From west line of N Ionia st west in center of Newberry st to east line of Canal st	Wood	36x48	792	63-64
Oakes	From center S. Spring st at south line of Oakes st thence west on curve to center of Oakes st thence west in center of Oakes st to near alley between S. Spring and S. Ionia sts, thence north on curve to center of alley at north line of Oakes st	Brick	48x60	181	1869
Ottawa	From north line of Walbridge st south in east gutter of Ottawa st to sewer in Newberry st	Brick	18x24	1311	1869
Ottawa	From 250 ft south of Trowbridge st north in east gutter of Ottawa to sewer in Newberry st	Brick	18x24	1415	1869
Ottawa	From east line of Ottawa st at center of Fountain st south on curves to sewer in Monroe st	Brick	24x36	111	1874
Ottawa	From 100 ft south of Monroe st south-westerly in center of Ottawa st to sewer in E Fulton st	Brick	16x24	792	1870
Pearl	From east gutter N Division st west in center of Pearl st to Canal st, thence across Canal st to south gutter of Pearl st thence west to the east channel sewer	Brick	16x24	502	1874
		Brick	16x24	479	1870
		Brick	36x48	187	1869
		Brick	48x60	155	1870
Plainfield Ave.	From south line of Carrier st south-westerly in center of Plainfield ave to Coldbrook creek	Glazed Pipe	15	327	1878
		Brick	18	367	1878
Plainfield Ave.	From 75 ft south of Coldbrook creek in center of Plainfield ave south-westerly to sewer in Coldbrook st	Glazed Pipe	12	445	1878
Pleasant	From point 6 ft east of west line of S Lafayette st west in center of Pleasant st to east line of alley west of Jefferson ave	Brick	16x24	307	1879
		Brick	18x27	300	1879
		Brick	20x30	200	1879
Prescott	From west line of S Division st west in center of Prescott st to S Ionia st	Brick	36x54	594	1878
Prospect, S	From 37 ft north of State st north in center of S Prospect st to Washington st, thence west on curve to sewer in Washington st	Glazed Pipe	12	430	1875
Ransom	From south line of Fountain st south in center of Ransom st to E Fulton st, thence west on curve to sewer in E Fulton st	Brick	20x24	52	1875
		Brick	20x24	756	1866
Sheldon	From 150 ft south of Island st on east line of Sheldon st northwesterly to near south-west corner of Island and Sheldon sts	Brick	36x48	172	67-68
Sheldon	From center of Wealthy ave at east line of Sheldon st south on curve to center of Sheldon st thence south to sewer in Wenham ave	Wood	36x48	609	1864
Spring, S	From center of Bartlett st north in center of S Spring st to south line of Oakes st	Brick	20x30	333	1869
		Brick	48x60	781	1869

STREET.	LOCATION.	MATERIAL.	Size in Inches.	Length.	When Built.
Taylor	From 12 ft north of E Leonard st north in east gutter of Taylor st to point 20 ft north of south line of Quimby st. Discharges into 18 inch pipe culvert 525 ft north of E Leonard st	Cement Pipe	9	513	1872
		Cement Pipe	12	1150	1872
Taylor	See Plainfield ave				
Walbridge	From east line of N Ionia st west in center of Walbridge st to sewer in Ottawa st	Brick	20x30	301	1871
Washington	From east line of Madison ave west in center of Washington st to near Jefferson ave, thence northwesterly to west line of Jefferson ave at point — ft north of the north line of Washington st	Brick	24x30	1283	68-69
		Brick	36x48	90	68-69
Waterloo, N	From 80 ft south of Monroe st southwesterly in center of N Waterloo st to sewer in E Fulton st	Glazed Pipe	18	960	72-73
Wealthy Ave	From west line of Cass st west in Wealthy ave to east line of Sheldon st	Wood	36x48	901	1864
Wenham Ave	From west line of S Lafayette st west in center of Wenham ave to east line of S Division st, thence south and west on curves to center of Prescott st at west line of S Division st	Brick	16x24	300	1876
		Brick	18x27	947	1876
		Brick	30x45	343	1876
Williams	From east line of S Ionia st east in center of Williams st to west line of S Spring st, thence north on curve to sewer in S Spring st	Brick	48x60	275	1875
Alley between Kent and Canal sts	From 63 ft south of Hastings st south to sewer in Lyon st	Brick	20x30	487	1870
		Brick	36x48	1157	1865
Alley between Canal and Ottawa sts	From north line of Walbridge st south to south line of Mason st	Glazed Pipe	12	787	1874
Alley between Kent and Ottawa sts	From south line of Trowbridge st south to sewer in Hastings st at point 10 ft west of west line of alley	Glazed Pipe	12	543	1872
Alley between Kent and Ottawa sts	From 75 ft north of Lyon st north to sewer in Bronson st	Glazed Pipe	12	460	1874
Alley between Kent and Ottawa sts	From 75 ft south of E Bridge st south to sewer in Bronson st	Wood	18x24	482	
Alley between Ottawa and N Ionia sts	From 50 ft south of E Bridge st south to sewer in Bronson st	Wood	12x12	507	1867
Alley between Ottawa and N Ionia sts	From 50 ft north of Lyon st north to sewer in Bronson st	Wood	12x12	467	1867
Alley between N Division and Bostwick sts	From south line of Bronson st south to Lyon st, thence west on curve to sewer in Lyon st	Cement Pipe	12	526	1871
Alley between Summit and Calder sts	From north line of Oakes st north to sewer in E Fulton st	Glazed Pipe	12	797	1874
Alley between Calder and Almy sts	From 40 ft north of Cherry st north to Island st, thence west on curve to sewer in Island st	Glazed Pipe	9	426	1873
		Glazed Pipe	12	449	1873

STREET.	LOCATION.	MATERIAL	Size in Inches.	Length in Feet.	When Built.
Alley between S Ionia and S Spring sts......	From north line of Oakes st north to point 150 ft south of Island st...	Brick	48x60	250	1869
Alley between Sheldon and Lagrave sts...	From 20 ft south of Goodrich st south to Wealthy ave, thence west on curve to sewer in Wealthy ave..	Glazed Pipe..	12	350	1874
Alley between Blakeley av & Pleasant st.....	From south line of alley south of Blakeley ave at center of alley east of Center st, thence west on curve to center of alley south of Blakeley ave, thence west to east line of Center st.......................................	Brick	20x30	207	1878
Alley between Center st and Jefferson ave..	From sewer in Pleasant st at east line of alley north on curve to middle of alley, thence north to south line of alley south of Blakeley ave..	Brick	20x30	370	1878
	From 393 ft west of S Union st in E Fulton st southwesterly to near west line of S College ave at point 263 ft south of E Fulton st............	Brick ... . Brick	20x30 24x36	300 100	1874
	From 170 ft north of Wealthy ave on east line of S Lafayette st west across S Lafayette st, thence southwesterly to sewer in Wealthy ave near west line of Cass st...............	Glazed Pipe..	15	440	70-71
	From 150 ft south of Island st on west line of Jefferson ave westerly to Sheldon st at point 150 ft south of Island st..............	Brick	36x48	591	67-68
	From 150 ft south of Island st in alley west of S Spring st northwesterly to sewer in Island st at west line of S Ionia st..................	Brick	48x60	248	1869
East channel sewer	From south line of Pearl st —— ft west of west line of Monroe st southerly to point 30 ft south of Louis st —— ft east of Campau st	Stone & Br'k	74x124	358	

WEST SIDE SEWERAGE, MAY 1, 1879.

STREET.	LOCATION.	KIND.	Size in Inches.	Length in Feet.	When Built.
Allen	From west line of Winter st east in center of Allen st to tail race	Glazed Pipe	18	1194	1872
		Brick	72	24	1876
Bowery	From west gutter of W Division st at south line of Bowery st east on curve to center of Bowery st, thence east to Winter st	Glazed Pipe	15	508	1869
Bowery	From east line Winter st east in north gutter to near west line of alley east of Mt Vernon st, thence south on curve to south line of Bowery st at center of alley	Brick	72	710	1876
Bridge, W	From 70 ft east of Front st west in center of W Bridge st to culvert at Winter st	Glazed Pipe	12	412	1875
		Glazed Pipe	15	828	1875
Bridge, W	From west line of Straight st east in center of W Bridge st to culvert at Winter st	Glazed Pipe	12	1795	1870
Bridge, W	From point 186 ft east of Fremont st west in north gutter of W Bridge st to Lane ave, thence to point in east gutter of Lane ave at south line of W Bridge st	Glazed Pipe	9	260	1871
		Glazed Pipe	12	327	1871
Court	From point 80 ft south of W Bridge st south in center of Court st to sewer in Valley st	Glazed Pipe	12	598	1873
Division, W	From north gutter of Sibley st north in west gutter of W Division st to south line of Bowery st	Glazed Pipe	15	982	1869
Fifth	From east line of Stocking st east in center of Fifth st to the Turner ditch	Glazed Pipe	12	2030	1871
Fourth	From west line of Stocking st east in south gutter of Fourth st to the Turner ditch	Brick	18x24	1733	68-69
Front, S	From south line of Valley st south near center of S Front st to Allen st, thence on curve to center of Allen st near east line of S Front street	Brick	72	452	1876
Fulton, W	From west line of Winter st east in center of W Fulton st to Gaand River	Glazed Pipe	24	66	1875
		Brick	22x33	572	1875
		Brick	24x36	510	1875
Jefferson, N	From north line of Third st south in center of N Jefferson st to center of Second st	Brick	18x24	397	1867
Second	From sewer in N Jefferson st east in center of Second st to the Turner ditch	Brick	18x24	834	1867
Second	From west line Scribner st west in center of Second st to the Turner ditch	Wood	12x18	834	1870
Sibley	From west line of Jefferson st west in center of Sibley st to east line of Straight st, thence west to point 10 ft west of west line of Straight st and 8 ft south of center of Sibley st	Glazed Pipe	15	328	1877
		Brick	16x24	330	1877
		Brick	22x33	321	1877
		Brick	24x36	10	1877
Summer	From 150 ft north of Shawmut ave north in center of Summer st to sewer in Bowery st	Brick	16x24	1115	1867
Third	From west line of Scribner st west in center of Third st to the Turner ditch	Glazed Pipe	9	816	1870

STREET.	LOCATION.	KIND.	Size in Inches.	Length in Feet.	When Built.
Third	From east line of Scribner st east in center of Third st to canal	Glazed Pipe	9	307	1870
Valley	From east line of alley between Mt. Vernon and Court sts east in north gutter of Valley st to S Front st, thence on curve to near center of S Front st at south line of Valley street	Brick	72	430	1876
Winter	From south line of W Bridge st south in east gutter of Winter st to Bowery st, thence on curve to north gutter of Bowery st at east line of Winter st	Brick	72	310	1876
Alley bet Court and Mt Vernon sts	From 40 ft north of Shawmut ave north to sewer in Allen st	Glazed Pipe	9	393	1873
Alley bet Court and Mt Vernon sts	From south line of Bowery st south to north gutter of Valley st at east line of alley	Brick	72	320	1876
Alley bet Summer and Mt Vernon sts	From 160 ft north of Allen st south to sewer in Allen st	Glazed Pipe	9	193	1873

REPORT

OF THE

CITY SURVEYOR

ON

ADDITIONAL

Water Supply

FOR THE

City of Grand Rapids.

◆

June, 1880.

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ADDITIONAL WATER SUPPLY

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CITY OF GRAND RAPIDS.

June, 1880.

GRAND RAPIDS, MICHIGAN:
W. W. HART'S ARCADE STEAM BOOK AND JOB PRINTING HOUSE.
1880.

REPORT.

To the Honorable Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—I have the honor to submit the following report concerning the relative value of various plans suggested for providing the city of Grand Rapids with an additional supply of water for public use, as directed by a resolution of your honorable Board, adopted June 7, 1879, a copy of which is as follows:

"*Whereas*, The Common Council of the city of Grand Rapids, at a session May 6, 1879, authorized the City Surveyor to make all necessary investigations, surveys, plans, etc., to furnish full, complete and, if possible, satisfactory data, to enable the Board to prepare and submit to the Common Council and the public a plan for procuring an abundant supply of the best obtainable water for the use of the city of Grand Rapids; therefore,

"*Resolved*, That the City Surveyor be and is hereby instructed to examine and report to this Board plans furnishing all facts necessary to exhibit the best method and sources to procure an additional supply of pure water, and the probable cost of its introduction; and, further,

"*Resolved*, That the examination be made to embrace, as possible sources of additional supply; Lamberton Creek, Lamberton Lake, Grand River, Coldbrook Creek and lakes supplying the same, Indian Mill Creek, or any other sources that promise satisfactory results."

At the time of the passage of the above resolution two reasons existed, either of which was, perhaps, sufficient to direct attention to the betterment of our water supply; and each continues to exist, and to become more and more apparent to our citizens. The first is, that the water now supplied is unsatisfactory to the public in point of quality. Complaints from water consumers are almost universal. The water is invariably muddy for some time after every considerable rain, and its hardness is so great as to almost entirely prevent its use for domestic and industrial purposes.

The two creeks from which the supply is drawn flow for a considerable distance within the corporate limits of the city, one its entire length; and this fact leads many to regard the water with suspicion, as likely to become polluted by sewage from dwellings situated near the creeks, and thus made unsafe for use.

The quality of the water has operated powerfully against the financial success of the works, so that now, after a lapse of five years from the completion of the works, the revenue from the sale of water is far short of what is necessary to meet the annual expenses of maintenance and the interest on the water bonds.

Annually there must be raised by general taxation about $24,000 to make up the deficit.

The second reason referred to, was that the present sources were fast becoming inadequate to meet the growing demand for water; not that it was not generally sufficient, but that in time of drought the danger of a water famine was becoming more imminent.

During the month of August of last year the supply became so reduced in amount, owing to a long-continued drought, and the consumption so increased from the same reason, that it became necessary to take decisive measures to reduce the consumption, and thus avert a possible disaster.

The last annual report of the engineer of the pumping machinery shows that, for the ten days ending September 2, 1879, the settling basin was pumped dry every day, and that the water in the distribution reservoir fell from its ordinary level of 20 feet, to 18 feet 3½ inches.

During the dry period above referred to, a number of measurements were made of the flow of Carrier Creek, which gave the following as the amount of the flow in gallons per twenty-four hours for the dates named:

August 25th—586,350 gallons.
" 28th—575,800 "
September 10th—573,000 "
" 12th—637,900 "

The average daily consumption during the ten days, as shown by the report, was 1,336,650 gallons, and had the consumption reached the average of 1,936,650 gallons per day, the reservoir would have been entirely exhausted. In other words, had the consumption during the period mentioned been 600,000 gallons per day more than it actually was, the reservoir would have been emptied; or had the drought continued for a short time longer, the same result might have occurred.

Our present system may be briefly described. The supply is drawn to the pumping station from the settling basin located in the northeastern portion of the city, at the junction of Coldbrook and Carrier Creeks.

The basin was, when first built, supplied almost, if not wholly, from Carrier Creek, which furnishes water the healthful quality of which has not been called in question.

A connection with the settling basin was made from Coldbrook Creek, to be used when the supply from Carrier Creek should be insufficient.

The rapidly increasing demand upon the water soon made it necessary to use the water of Coldbrook Creek, the quality of which was regarded with suspicion, as the creek flows for some distance through a well-settled district, and liability to pollution is thereby engendered.

The continued use of Coldbrook water was soon followed by complaints from consumers of water. It was not considered, however, until the Spring of last year that the quantity of water which could be supplied was likely to soon prove insufficient.

As illustrating the annual increase in our water consumption, the following table is appended, showing the amount of water used each year ending April 30th, the annual per cent. of increase, and the daily average consumption for each year:

Year endi'g April 30.	Total No. gals. of Water Pumped.	Increase in gals. over Previous Year.	Per cent. of Increase.	Average Daily Consumption.
1877	237,924,300	....	...	651,023
1878	251,169,575	13,245,275	.05	688,108
1879	327,413,707	76,244,132	.30	897,024
1880	404,209,900	76,796,193	.23	1,107,424

Before discussing the proposed sources of additional supply, I shall endeavor to determine, as far as possible, first, the quantity of water it will be advisable to secure for the future use of the city; second, to show what is desirable and undesirable, so far as quality is concerned; third, to state some of the general principles relating to the collection and storage of water.

Undoubtedly the best water that can be obtained in sufficient quantity should be procured, provided the cost does not place it beyond our reach.

QUANTITY OF WATER REQUIRED.

The quantity of water needed in the future will depend largely on the increased growth of the population. Although there is no fixed ratio of consumption to population, the experience of all cities showing different results, still the quantity needed can be approximately estimated when the population to be supplied can be determined.

The following table exhibits the growth of our city from 1850 to 1879, as ascertained from the State and government census reports, and from the annual census of school children:

Year.	School Census.	Actual populat'n, State and Gov't Census.	No. of persons for each school child.	Population estimated from School Census.
1850	....	2,686	...	2,686
1860	2,362	8,084	3.42	8,084
1865	2,757	....	3.43	9,456
1869	4,354	....	...	....
1870	4,766	16,507	3.46	16,507
1871	5,199	....	...	....
1874	7,961	25,923	3.25	25,923
1875	8,400	....	3.25	27,300
1879	9,559	....	3.30	31,545

The number of persons to each school child in 1860 was 3.42, in 1870 about 3.46, the school census for that year being estimated from that of 1869 and 1871, and in 1874 the ratio was 3.25.

The population for 1875 and 1879 has been estimated from the school census of those years, the ratio being taken at 3.25 and 3.30. The population will be again determined by government census in June, at which time the population will probably be nearly 34,500. *

The following table exhibits the percentage of growth for each period of five years of a number of American cities at different stages of their growth. It is based on their actual population, as taken from the United States census reports:

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* Since this was written the census has been completed, which gives the population on June 1 as 32,087.

30,000.	Per ct.	50,000.	Per ct.	70,000.	Per ct.	100,000.	pr ct
Buffalo, N. Y...	52	Albany, N. Y...	23	Albany, N. Y...	25	Buffalo, N. Y...	21
Brooklyn, N. Y.	54	Brooklyn, N. Y.	64	Brooklyn, N. Y.	64	Brooklyn, N. Y.	66
Cleveland, O...	60	Buffalo, N. Y...	39	Buffalo, N. Y ..	39	Baltimore, Md.	13
Columbus, O...	30	Cincinnati, O...	58	Boston, Mass..	23	Boston, Mass...	21
Cincinnati, O...	37	Cleveland, O...	46	Cincinnati, O..	55	Cincinnati, O...	58
C'mbridge, Mass	23	Detroit, Mich..	32	Cleveland, O...	46	Louisville, Ky..	22
Chicago, Ill.....	92	Louisville, Ky..	25	Detroit, Mich..	32	Newark, N. J...	21
Detroit, Mich..	47	Milwaukee, Wis	26	Louisville, Ky..	22	New Orleans, La	49
Dayton, O......	23	Newark, N. J...	36	Milwaukee, Wis	26	Providence, R. I.	46
Fall River, Mass	69	New Orleans, La	49	Newark, N. J...	36	Philad'lphia, Pa	14
Hartford, Conn.	13	New Haven, Con	14	New Orleans, La	49	St. Louis, Mo..	43
Indianapolis, In	61	Providence, R.I.	9	Pittsburg, Pa..	33		
Louisville, Ky.	44	Pittsburg, Pa..	33	Providence, R.I.	46	Average.....	34
Lowell, Mass...	46	Rochester, N.Y.	14	Rochester, N. Y.	31		
Lawrence, Mass	20	Richmond, Va..	16	St. Louis, Mo..	117		
Lynn, Mass....	16	St. Louis, Mo..	117				
Milwaukee, Wis	50			Average.....	42.9		
Memphis, Tenn	34	Average.....	37				
Newark, N. J...	50						
New Haven, Con	39						
Pittsburg, Pa..	49						
Providence, R.I.	33						
Paterson, N. J..	31						
Portland, Me...	09						
Rochester, N.Y.	34						
Richmond, Va..	17						
Reading, Pa....	21						
Syracuse, N. Y.	24						
St. Louis, Mo..	68						
Troy, N. Y......	17						
Toledo, O.......	51						
Wilmington, D'l	20						
Worcester, Mas.	29						
Average.....	38						

As will be seen from this table, the average growth of American cities having a population of 30,000 has been 38 per cent. for each five years.

At the time the population of each was 50,000, the average growth for five years was 37 per cent.; when passing 70,000, 42.9 per cent., and when passing 100,000, 34 per cent.

It would probably be unsafe to predicate a growth for this city much less than the average. The history of its previous growth, the present indications of prosperity, and the recent large increase in the number of manufacturing corporations, would not warrant such an assumption.

There is hardly a city in the United States that is not lamenting that the projectors of its water works system underestimated the future population, and consequent demand for water.

Assuming the future growth of Grand Rapids during the present century to be 33⅓ per cent for each five years, we have the following as the estimated population in the immediate future:

Year.	Population.
1880	34,500
1885	46,000
1890	61,333
1895	81,777
1900	109,036

The past growth of the city has been as follows, expressed in per cent. of increase for each five years:

From 1850	to 1860	73 per cent.
" 1860	" 1870	43 "
" 1870	" 1875	65 "
" 1875	" 1880	25 "

Assuming that the future increase will be no more rapid, but equal to that of the last five years, which have covered a period of great financial depression, namely, 25 per cent., we have a future estimated population as follows:

Year.	Population.
1880	34,500
1885	43,125
1890	53,906
1895	67,382
1900	84,227

I am of the opinion that it would be unwise to construct permanent works that would not furnish, in the year 1900, sufficient water for 100,000 people, or that were not essential portions of a system that would, when completed, furnish such an amount.

The earlier estimates of American engineers allowed from 50 to 60 gallons as the average amount of water needed per day per individual, and those estimates have, in nearly all the larger cities, proved too small.

The following table, from the annual report of the Boston Water Board, 1879, shows the average quantity of water used per day per individual in various American cities:

CITY.	Year.	Population	Av. d'ly con. per h'd in gal.
Chicago	1877	440,000	119
Detroit	1877	110,200	105
Buffalo	1877	135,000	87
Toronto	1877	75,000	77
Boston (Mystic works)	1877	110,000	76
Boston (Cochituate works)	1877	280,000	74
Boston (Cochituate and Mystic)	1877	390,000	74
Montreal	1877	130,000	69
Brooklyn	1877	485,000	63
Philadelphia	1877	817,500	58
Cincinnati	1877	280,000	57
St. Louis	1877	400,000	56
Cleveland	1877	136,000	56
Cambridge	1877	48,000	55
Milwaukee	1877	130,000	53
Lawrence	1877	35,000	44
Columbus	1876	34,000	43
Rochester	1877	82,000	35
Lynn	1877	32,600	34
Lowell	1877	50,000	33
Fall River	1877	45,000	26
Providence	1877	100,000	25

It is probable that our consumption is not likely to exceed 60 gallons per day per capita during the present century, and hence it may be assumed with considerable safety that (100,000 x 60) 6,000,000 gallons per day is a reasonable estimate of the average daily consumption in the year 1900.

The present average daily consumption is about 38 gallons.

The future consumption may be assumed as follows:

Year.	Population.	Consumption.
1885	46,000	2,760,000
1890	61,000	3,660,000
1895	82,000	4,920,000
1900	109,000	6,540,000

So far as average daily consumption per individual is concerned, I am well assured that the estimates above given are entirely safe. I am quite of the opinion that the next twenty years will witness a more general introduction of water meters, which have been found to restrict consumers of water to its legitimate use. It is also quite probable that the water meter will also be so improved and cheapened as to make it in the interest of the water taker to purchase his own meter, and thus avoid the payment of such rates as are made necessary by his neighbor's wasteful use.

QUALITY.

The question of quality is one of the most important which we have to examine.

The future health and comfort of the people, and the future commercial and industrial prosperity of our city, are probably more dependent upon a satisfactory solution of this question than any other which affects our condition.

All natural waters are more or less charged with foreign substances. The rain absorbs them from the atmosphere. The water falling upon the surface of the earth dissolves and takes into solution portions of almost every substance with which it comes in contact. Owing to its high specific gravity, it lifts up and holds in suspension often a large amount of foreign matter.

It is important, therefore, to know what impurities are most to be avoided, how they may be avoided, and how they may be or are destroyed when once they find their way into our water supply.

It is desirable that the water furnished should be at all times wholesome and safe in use, clear and limpid, and as free as possible from foreign substances that would render it undesirable for domestic and manufacturing purposes.

The foreign matters found in natural waters are divided into two classes, inorganic and organic, the first consisting of the products of mineral substances, the second of animal and vegetable substances.

It is not difficult to say whether or not a water is wholesome by reason of the inorganic substances which it may contain, when these have been determined. Thus, if a water is known to contain an appreciable amount of any poisonous metal, as lead, arsenic or antimony, no doubt would exist as to its dangerous quality.

The study of organic matters, however, presents greater difficulty. Organic matters are divided into two classes: animal, derived from the products of animal life, and the decomposition of animal substances; and vegetable, derived from the solutions and decompositions of vegetable substances.

Vegetable organic matter in water is not generally considered harmful, except, possibly, when in certain stages of decomposition. Animal organic matter, on the other hand, especially from sewage or the waste from human beings, is the most fearful of all pollution, and the most difficult to destroy.

Hence, it is important, in speaking of organic matter, that the *kind*, whether animal or vegetable, should not be lost sight of; for it is of vastly more importance to know the kind or character of the organic matters in water rather than simply the amount. Thus, a cup of tea or coffee is simply water highly charged with vegetable organic matter, and if not in a state of decomposition, it is usually considered wholesome. On the other hand, a glass of distilled water polluted with an almost infinitesimal amount of infected sewage would be dangerous in the highest degree, while a simple statement of the *amount* of organic matter it contained would excite no suspicion whatever. Hence, it might be said that the quantity of organic matter is not always a guide to a correct opinion.

There is at present no method known by which the total amount of organic matter in water can be determined, and it is not possible to ascertain precisely the kind and condition of those portions which do yield to the chemist's tests.

So accustomed are many people to this expression, "organic matter," that it is well to insist that the term is one which conveys but little real meaning. The history of a water and its surroundings is in all doubtful cases necessary to a correct opinion as to its quality.

Water is a most potent vehicle for the transmission of disease, or that "something" which produces it. Whether sickness is induced by living organisms, which develop and thrive, perhaps, at the expense of our lives; or by decompositions set up in our systems by decomposing substances that we may eat, drink or inhale, the fact remains that, if our drinking water has, from the time when it was first condensed in the clouds to the time when it passes into the human system, while in its devious passages through soil, creek or well, encountered any products of decomposing animal matter or sewage, it takes up and transmits to us certain elements which render it dangerous to human health.

So important is this fact that every person should advise himself of the history of the water which he drinks. Near Over-Darwin, England, a person who had contracted typhoid fever came home and died. The dejecta of this patient were thrown into a closet which drained into an adjacent field. Through this field was laid a concrete water main, which conveyed the town supply. This main was not tight, and some of the sewage from the closet penetrated through the water pipe, and in this way was conveyed to the people in the town. The violence of the outbreak of typhoid fever attracted universal attention. In a short time two thousand and thirty-five persons were attacked, and one hundred and four died.

Of vegetable organic matter, it may be said, generally, that the less of it in potable waters the better. As shown in the cup of tea, a large amount may be harmless, as would a large amount of animal organic matter be when in a wholesome state, as in beef tea.

Peaty waters are regarded as wholesome. Water from the Dismal swamp, called juniper water, is as highly colored as pale brandy, yet it has been in high repute for supplying ships, and found to be healthy to use. On the other hand, it is considered that natural waters containing a large quantity of dissolved vegetable matter, or vegetable matter in suspension, have been known to cause sickness, and it has been popularly acknowledged to be productive of malarious diseases.

It is considered that vegetable matters in water in various stages of decomposition are likely to produce disease, or a low physical condition which may open the door to diseases of a very different character than those usually attributed to unwholesome water, and as it is not entirely possible for the chemist to determine upon the particular *condition* of the organic matter in a water, and particularly as these conditions are as changing as the clouds or winds, it follows that the greatest freedom from organic matter is desirable, even if it is generally a harmless constituent.

Natural waters adapted for city supplies usually fall under one of the following heads:

Rain water.
Upland surface water.
Surface water from cultivated lands.
Shallow well water.
Deep well water, and
Spring water.

Rain water collected on clean surfaces is comparatively pure, although often containing ammoniacal salts, carbonic acid and organic matter.

Upland surface waters contain, usually, a considerable amount of mineral and organic substances, being largely influenced by the nature of the soils over and through which the water passes.

In surface water from cultivated lands, the foreign matters may be very great, and such waters may be dangerously contaminated from the applications of the various manures.

In shallow well waters, impurity of all kinds is, as a rule, greatly increased, a shallow well being, to a certain extent, a drain for the surrounding soil. "Such water, although often most disgustingly con-"taminated, is usually bright, sparkling and pala-"table, the saline flavor due to the salts in solution, "and which is sometimes very pronounced, being "often much approved by those who are accustomed "to it." (*Lippincott's New Encyclopedia of Chemistry.*)

Deep well waters frequently contain much mineral, but generally but little organic matter, this having been removed by oxidation in passing through the soil.

Spring waters closely resemble the preceding class, their conditions being almost identical.

All the waters which have been proposed for additional supply are very variable in point of quality, becoming highly charged with foreign substances with every considerable increase of volume. The river is a familiar example, becoming turbid after every heavy rain, and its turbidity lasting often for considerable periods.

It will, therefore, be necessary to employ means of purification.

The principal operations carried out on the greatest scale by nature for the purification of surface waters are—

Filtration.

Subsidence and Precipitation.

Thus, water falling upon the earth's surface and there becoming loaded with dissolved products of vegetation and soluble earths, is rendered clear again by percolating through sandy or porous strata, the foreign organic matters being removed from the water chiefly by mechanical means. The conditions necessary for furnishing small quantities of clear and cool spring water—that is, water filtered by natural processes—may be found in very many localities, and hence such waters are popularly in much repute. Such spring waters often contain, however, such amounts of dissolved mineral matters as render them undesirable for domestic or manufacturing purposes.

Not less important are the natural processes of subsidence, precipitation and oxidation for purifying surface waters. The waters of many of our favorite lakes have been clarified by these natural processes.

When the turbid and often highly colored waters of a storm-swollen stream are discharged into a great lake or reservoir, the heavier particles of suspended matter sink to the bottom, carrying with them lighter substances that might otherwise remain for a much longer time in suspension. Organic matters are brought in contact with atmospheric oxygen contained in the water, and thus destroyed or broken up, and converted into harmless gases which pass into the atmosphere, and mineral residues which sink to the bottom of the water.

Natural waters are sometimes rendered impure by the growth of minute animal and vegetable life. Stored waters in natural or artificial lakes are liable, under certain conditions, to acquire an unpleasant taste or odor, the causes of which have not been definitely ascertained. It has been thought that the minute organisms, which sometimes multiply with astonishing rapidity, give rise by their speedy death and decay to that which causes the trouble.

A study of the microscopic animal life in water is often of value as affording an index to its condition, certain species being rarely found except in water that is confessedly unwholesome or polluted, while other species, by their presence, would indicate that the water was of a desirable quality.

Waters stored in recently constructed impounding reservoirs are likely to acquire an objectionable amount of color, which arises from the decomposition of vegetable matters, which are not always removed before the water is impounded. It has been found, however, that this difficulty ceases after a few years, the organic matters in the bottom of the lake becoming entirely decomposed, or their soluble parts dissolved out.

Should, however, the lake have an undue proportion of shallow flowage, which facilitates the growth of minute animal and vegetable life, this desirable result might not be realized.

HARDNESS.

Certain foreign substances in water give it the power of destroying soap. This quality is known as "hardness," and is usually expressed in degrees, each degree on Clark's scale being equivalent to that hardness produced by dissolving one grain of pure carbonate of lime in one imperial gallon of distilled water.

Thus a water of twelve degrees of hardness, Clark's scale, is water having a soap-destroying power equal to that produced in one imperial gallon of distilled water by dissolving therein twelve grains of pure carbonate of lime. Water of two or three degrees of hardness is called soft water. When the hardness reaches twelve or fifteen degrees it is excessive, and the value of the water is greatly reduced for detergent and many manufacturing purposes.

When hard water is boiled, carbonic acid gas is driven off and carbonate of lime is precipitated, forming fur or scale, the bane of steam users. The hardness is, by the process of boiling, reduced, and the hardness which remains and cannot be removed by boiling is called the "permanent hardness," as opposed to the "temporary hardness," which boiling removes.

A great deal of discussion has occurred relative to the sanitary values of hard and soft waters. It has been asserted that hard waters produce and aggravate certain diseases, as calculus, goitre, urinary and dyspeptic affections, and many statistics have been prepared to establish the facts. It has also been asserted that a certain amount of lime salts is essential to proper health and development. The best conclusion seems to be that, "while waters of "excessive hardness may possibly be injurious, it "appears that, apart from these, waters of all "degrees of hardness are equally wholesome, other "conditions being similar." (*Lippincott's New Encyclopedia of Chemistry.*)

Hard waters may be deprived of their temporary hardness by boiling, by the introduction of carbonate of soda, and by the lime-softening process of Dr. Clark, which will hereafter be more fully described.

Partial analyses have been made of the various waters which have been proposed for additional supply by Hugo Thum, Ph. C., whose report will be found in the appendix.

The method used for determining organic matters has been that known as the ammonia process of Wanklyn and Chapman, which is now in general use in this country. The method consists in first boiling the water with carbonate of sodium to drive out the ammonia, which is derived chiefly from the decomposition of organic matter, and, second, by converting the remaining nitrogen, which is in combination with other elements in the organic matter, into ammonia, by boiling it with a strongly alkaline solution of potassic permanganate. This latter is called the "albuminoid" ammonia, to distinguish it from the free ammonia first expelled, because all the nitrogen in albumen can thus be converted into ammonia.

An examination of the chemist's report will show that the waters from the various sources examined are, to a certain extent, of the same general character, and that the normal amounts of organic matter are higher than is desirable.

It may be well to say here, however, that no evidence of sewage pollution, or of contamination from animal organic matters, has been noticed, and that, substantially, all of the organic matters indicated by the results may be regarded as of vegetable origin.

In order that comparisons may be made with other waters, a table is annexed showing the results of similar analyses; but in examining this table, it should be remembered that each water is liable to wide variations at different times, and that, unless the conditions and characteristics of each specimen are known, fair comparisons are impossible. The table will, however, be of interest to those who are interested in the subject.

STORAGE AND COLLECTION.

With the exception of the river, all of the sources that have been proposed are not of sizes which assure a sufficient quantity of water for our future use without special examination, and, therefore, it may be well to state some of the facts which have to do with the subject of water supplies in general, their quantities and characteristics of flow.

The source of all water supply is found in the rains and snows which fall upon the surface of the earth, and, although the statement may seem to express a fact apparent to all, its careful consideration may enable us to avoid error.

I meet persons who seem to think that a broad expanse of water-soaked earth, dotted, perhaps, with numerous springs, is a possible source of water, and that it is only necessary to tap such springs to draw from the mysterious regions of the earth inexhaustible supplies. A part of the water precipitated upon the earth flows over its surface into the brooks and rivers as surface water; another portion sinks into porous strata to reappear in springs; another portion is absorbed by growing vegetation.

From the time a drop of rain falls upon the earth until it reaches, by spring, rivulet, creek or river, the parent source, the ocean, its course, when not confined, as in pipes, is continually downward and never upward, until it is caught up as vapor by the evaporating power of the sun's rays. Hence, we find for every spring, lake or river, gathering grounds or catchment areas exposed to the falling rains, which are located on higher levels than the water under examination.

It is a fact now well established that the amount of water which annually flows from a spring or along a creek or river bears a direct relation to the area drained. The larger the drainage area the greater will be the quantity of water drained away.

Of the water falling upon the surface of the ground, a part is returned to the atmosphere by evaporation, and thus lost for purposes of supply, the amount evaporated depending upon a multitude of complex conditions which it is unnecessary to consider here.

If, then, it is practicable to determine the area drained by any stream, the amount of rainfall that is precipitated upon it, and the percentage that will be lost by evaporation, etc., then it is possible to predict, within fairly accurate limits, the annual yield of the stream for purposes of supply.

Long continued observations in this and other counties go to show that, of the total mean annual rainfall, there may be collected approximately as follows:

From steep, rocky slopes, 80 to 90 per cent.

From swampy lands, 60 to 80 per cent.

From undulating pasture and wood, 50 to 70 per cent.

From flat cultivated lands and praïrie, 45 to 60 per cent. (*Fanning's Water Supply Engineering.*)

The amount of water that may be secured from a given stream for purposes of public water supply is, therefore, limited to the amount of rainfall upon its gathering grounds, subject to deductions as above indicated, and which amount to from 20 to 60 per cent. of the total.

It is also held, on the other hand, that the amount of rainfall collectable in the stream is not properly a percentage of the annual rainfall, but that the annual loss by evaporation, etc., is more properly a fixed quantity, although varying within considerable limits, and the latter opinion seems to be the best established by the experience which has been gained from long observation. As the annual rainfall fluctuates within wide limits from year to year, and the monthly rainfall varies widely from the average, a careful study of the same becomes of the greatest importance.

The safe measure of a stream for purposes of supply is its measure during the year when the *least* amount of water flows through it; and, as the daily flow is frequently greatest when the demand for water is least, and least when the demand for water may be greatest, the necessity arises for the storage of the surplus water in wet periods: that is to say, in order to make available the entire yield of the stream in any year, it is necessary to provide storage room in which to hold the surplus or storm waters.

In determining, therefore, upon the quantity that may be depended on from a given stream under any and all unfavorable conditions that may occur, two practical questions arise:

First—What quantity of water will reach the storage pond during the year of least flow, which is not necessarily the year of least rain? and,

Second—What storage capacity is necessary to secure the same without loss?

The following tables exhibit the annual rainfall for the years named at Lansing, Detroit, Grand Haven and Grand Rapids. The observations in Grand Rapids were made by Mr. Louis H. Streng; those at Lansing by Prof. R. C. Kedzie, and those at Detroit and Grand Haven by the United States Signal Service:

MONTHLY RAIN FALL.

AT GRAND RAPIDS, MICHIGAN.

MONTHS.	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879
January	....	....	....	....	....	....	....	3.36	5.34	2.26	3.53	4.78	1.68	2.64	1.37	1.02	1.25
February	....	....	....	....	....	....	....	1.66	1.44	0.86	1.50	0.93	3.66	1.76	0.02	1.69	2.01
March	....	....	....	....	....	....	....	2.71	3.50	2.00	2.94	3.60	2.35	2.64	3.81	4.05	0.85
April	....	....	...	....	....	....	....	1.88	3.39	2.23	2.65	1.18	1.63	1.97	3.70	5.54	1.27
May	....	....	....	....	....	....	....	0.87	1.39	3.49	4.14	2.02	2.91	4.71	1.31	3.10	2.50
June	....	....	....	....	....	....	....	6.15	3.77	3.18	2.02	6.44	1.38	7.82	3.32	2.32	1.94
July	....	...	....	....	....	....	....	5.55	1.68	1.93	6.23	1.74	2.72	3.74	3.22	3.21	2.40
August	....	....	....	....	....	....	....	2.04	2.35	3.99	0.80	0.52	3.74	0.76	3.81	2.08	1.28
September	....	....	....	....	....	....	....	3.10	0.76	10.03	3.44	2.70	4.64	4.39	0.68	3.25	4.53
October	....	...	....	....	....	....	....	4.84	2.71	0.90	3.77	1.72	5.16	0.57	....	5.20	1.98
November	....	....	....	....	....	....	....	0.72	2.10	2.03	1.96	2.38	1.28	2.32	5.59	0.98	6.46
December	....	....	....	....	....	....	....	3.89	2.50	1.80	2.08	1.02	2.72	1.81	0.95	3.41	3.49

AT LANSING, MICHIGAN.

MONTHS.	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879
January............	Not tak'n	0.94	0.65	2.03	1.68	1.47	0.87	1.93	3.95	0.43	2.98	3.53	1.81	1.63	1.33	1.12	....
February...........		0.27	1.76	2.23	3.23	1.28	2.95	1.21	1.73	0.49	0.77	1.55	2.20	3.04	00.0	2.74	....
March		2.26	2.79	3.39	0.68	4.65	1.65	3.00	3.91	2.04	1.73	1.79	1.02	4.84	5.60	3.12	....
April	1.54	3.80	2.32	1.47	2.19	1.83	3.42	2.02	2.97	1.26	3.88	1.67	0.61	2.08	4.14	3.76	....
May................	4.51	2.87	1.77	3.48	3.81	2.80	2.05	1.16	1.97	3.72	3.05	1.77	4.46	4.13	2.23	3.44	....
June................	2.30	3.88	3.55	5.36	2.83	3.55	4.40	7.27	2.93	3.45	2.96	5.07	1.84	4.34	3.53	3.15	....
July................	3.82	1.25	3.90	4.19	1.78	1.10	5.77	8.02	3.10	3.36	5.12	2.56	2.42	2.10	2.25	2.96	....
August.............	3.03	0.40	3.38	3.44	1.74	2.42	4.85	4.58	1.42	4.18	0.79	1.28	1.47	1.28	6.55	1.85	....
September..........	0.89	3.53	4.80	5.80	1.42	2.95	1.43	2.85	0.79	5.21	3.50	1.27	2.89	3.65	1.38	3.43	....
October............	1.04	1.85	2.79	3.56	2.11	1.11	1.72	2.29	1.43	0.67	1.91	0.49	5.81	1.26	5.69	1.99	....
November..........	0.88	4.12	0.68	2.60	1.74	2.44	1.93	0.91	1.25	0.98	2.03	1.61	1.11	0.91	3.67	2.16	...
December..........	1.71	3.20	1.43	1.90	1.34	1.35	2.11	2.57	1.76	1.06	3.02	0.87	2.80	1.29	1.03	2.27	....

AT GRAND HAVEN, MICHIGAN.

MONTHS.	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880
January	Office Opened in Oct. 71.	1.54	*	*	*	3.67	1.53	1.34	1.81	2.64
February		0.64	0.91	*	*	2.41	0.09	1.42	1.86	2.05
March		1.64	1.62	*	0.31	1.99	3.15	4.51	1.19	1.92
April		2.31	2.24	*	2.33	3.18	4.48	2.10	1.59	6.48
May		2.94	5.42	2.23	4.14	5.42	2.10	2.57	2.46	4.19
June		2.27	4.15	5.70	1.74	9.35	4.18	1.85	2.42	....
July		1.46	3.25	4.19	2.53	3.51	1.42	2.27	2.61	....
August		6.31	1.95	1.19	2.39	1.82	1.52	3.34	2.47	....
September		9.37	2.30	5.05	3.29	6.24	0.67	3.04	6.01	....
October	1.75	0.84	2.50	1.48	6.17	2.28	6.45	6.27	2.58	....
November	2.33	2.02	*	2.43	1.44	5.26	6.47	1.44	7.23	....
December	1.38	*	*	0.88	2.79	1.16	3.97	3.59	3.25	....

* No Record.

ANNUAL RAIN FALL.

Years.	Gd. Rapids.	Lansing.	Detroit.	Gd. Haven.
1863..........	.....	19.72	.....	.....
1864..........	.....	28.37	.....	.....
1865..........	.....	29.82	.....	.....
1866..........	.....	39.45	.....	.....
1867..........	.....	24.55	.....	.....
1868..........	.....	26.95	.....	.....
1869..........	.....	33.15	.....	.....
1870..........	36.77	37.76	.....	.....
1871..........	30.93	27.21	.....	* 5.46
1872..........	34.52	26.85	.....	†31.34
1873..........	35.06	31.74	34.00	‡24.34
1874..........	29.03	22.96	26.63	§23.15
1875..........	33.87	28.44	33.71	‖27.13
1876..........	35.13	30.55	40.40	46.29
1877..........	†27.78	37.42	35.23	36.03
1678..........	35.85	31.99	43.39	33.74
1879..........	29.96	.....	37.17	35.48
1880..........	.....	.....	.....	–17.28
Average	33.16	29.64	35.79	29.50

* Three months; † Eleven months; ‡ Nine months; § Eight months; ‖ Ten months; – Five months.

It is somewhat unfortunate that the rainfall tables for this section do not cover a longer period of years, as it is only by long-continued observations that we are sure of obtaining the rainfall of the lowest year. The least noted at Lansing was 22.96 inches in 1874, and the least in Grand Rapids was 29.03 inches, in the same year. I think as low as 20 inches have been observed at Detroit, but the record is not at hand. The least rainfall in Milwaukee in a period of twenty-three years was 20.54 inches.

I think it would be unwise to base calculations on a minimum rainfall of more than 20 inches.

In the Eastern States it has been customary to calculate on about 15 inches as the amount which might be collected in a dry year, but it is now considered that 12 inches is all that can be safely relied on, the least rainfall being about 35 inches.

The measurement of the flow of Lamberton Creek showed that, during July, August, September and October of last year, the amount of water in the stream averaged about 0.34 of an inch in depth per month over the drainage area, and if the same average flow had continued during the year, only 4.08 inches could have been collected.

But this flow at times was very small, and the rainfall for the six months preceding was less than for any period of six months of which I have any record.

From the best information at my disposal, I am of the opinion that it will probably be safe to make calculations on nine inches as the annual depth of water on the drainage area, or 428,500 gallons per day per square mile, as the average amount collectible from such districts as we have to consider.

In regard to the amount of storage capacity required, experience has demonstrated that, in order to make available the entire yield of the dryest year, about one-third of the total yield must be stored; and to make available the average of the three dryest consecutive years, which is one-sixth less than the yearly average of a long term of years, about one-half of one year's supply must be stored.

Three and one-half inches deep over the area drained will probably furnish sufficient storage for the dryest year or, year of least flow, or, in round numbers, 61,000,000 gallons per square mile of area drained.

In England, storage reservoirs have been built to utilize the flow of the three dryest consecutive years.

The following is the reservoir capacities of some English water works, expressed in million gallons per square mile of drainage area:

Manchester Water Works	117
Liverpool	233
Dublin	123
Glasgow, Loch Katrine district	145
" Gorbal's "	252

LAMBERTON LAKE AND CREEK.

Lamberton Lake may be called the popular favorite source for future additional supply. It is considered by our citizens generally as a body of beautifully clear and cool water, whose excellence was beyond question.

I have carefully examined this source with reference to the quantity of water it could furnish, in connection with the creek. Lamberton Lake is situated on sections 4 and 5 in the township of Grand Rapids, and is two miles north and one mile east of the northeast corner of the city.

It is supplied principally from an inlet which comes from Button Lake, situated a short distance east. Its outlet flows south a short distance, where it unites with the south branch of Lamberton Creek. The south branch of Lamberton Creek starts from Mud Lake, which is about one and one-quarter miles southeast from Lamberton Lake. It flows westerly and northwesterly, uniting with the Lamberton Lake outlet, and thence flows westerly to Grand River.

In order to determine experimentally the flow of these sources, two measuring weirs with thin galvanized iron overfalls were constructed, and one located on the south branch of Lamberton Creek, the other on the main stream a short distance below the upper Plainfield road. Hook gauges with suitable vernier plates were provided, so that the depth of water flowing over the weirs could be determined to the nearest thousandth part of a foot, and means were also provided for contracting the overfall during times of low water, so as to reduce, as far as possible, the liability to error.

The difference of flow between these two stations gives approximately the flow for Lamberton Lake itself, for which no measurements were directly taken.

Measurements were commenced July 1, and were continued until the 10th of December. One hundred and forty-nine measurements were made at the lower weir, and eighty-seven at the upper weir.

The following table shows the estimated discharge:

MONTHLY FLOW OF LAMBERTON CREEK, AT UPPER PLAINFIELD ROAD, 1879.

MONTH.	Total Discharge, gals.	Average Daily Flow.
July	46,421,400	1,497,465
August	41,463,970	1,337,547
September	62,129,350	2,070,978
October	61,562,280	1,985,880

The following shows the estimated flow of the south branch of Lamberton Creek during the same time:

MONTH.	Total Discharge, gals.	Average Daily Flow.
July	12,807,800	413,155
August	11,947,700	385,410
September	16,900,420	563,347
October	14,943,500	482,050

The estimated discharge for Lamberton Lake during the same period is as follows:

MONTH.	Total Discharge, gals.	Average Daily Flow.
July	33,613,600	1,084,310
August	25,516,270	823,105
September	45,228,930	1,507,631
October	46,618,780	1,503,831

The period of least flow may be taken from August 23d to August 31st, a period of seven days.

The total flow of the main creek for this period was 8,409,597, an average of 1,201,379 gallons per day. The average during the same period for the south branch was 330,970, and for Lamberton Lake 870,400.

There were noted on Lamberton Creek as follows, during November and December, discharges at the rates given:

Month.	Date.	Gals. per Day.
November	5	1,625,790
"	11	5,697,025
"	12	6,361,245
"	13	3,853,726
"	14	3,574,455
"	19	2,080,685
"	24	1,745,010
"	28	8,940,510
December	10	10,769,430

The greatest flow noted on Lamberton Creek was on December 10th, at which time the discharge was at the rate of 10,769,430 gallons per day, and the least flow noted was August 2d, at the rate of 1,144,296 gallons per day.

The least flow from Lamberton Lake was 840,890.

QUANTITY FROM LAMBERTON LAKE AND CREEK.

The drainage area of Lamberton Creek and Lake, as estimated from the surveys of its water-shed, is 6.44 square miles, including water surfaces. No measurement was made of the water-shed of Lamberton Lake itself.

Taking the amount of water that can be collected in the year of least flow at 428,500 gallons per day per square mile, or 9 inches over the area drained, as shown under the head of "Collection and Storage," we have, as the mean daily flow of Lamberton Creek at the upper Plainfield road for purposes of water supply, 2,759,540 gallons per day.

To secure and make available the surplus of wet periods, as in December, when the flow exceeded ten million gallons per day, we assume that room for three and one-half inches over the entire water-shed will be sufficient, which gives 392,840,000 gallons as the storage room required on Lamberton Creek to make available its least annual flow for purposes of supply.

Manifestly, the simple fact that this stream fluctuates in its flow, as we have seen, from about one and one-fifth million gallons to perhaps eighteen or twenty millions per day, and that it almost invariably happens that the least flow is at the time of greatest consumption, furnishes abundant proof of the necessity for storing the surplus water.

The following table will illustrate this, and show how the amount of storage needed may be estimated. It is based upon the assumption that the creek can furnish a daily average of 2,760,000 gallons, and that the daily average consumption is the same amount.

The ratios of monthly consumption are the same as are exhibited by our actual city consumption during the past year, and the flow for the summer months is taken as observed last summer, the flow for the balance of the year being assumed. To simplify matters, the evaporation which would take place from the storage pond is omitted. The results are not to be taken as accurate, my purpose being to indicate the method by which required storage can be ascertained before works are constructed, when the necessary data have been obtained.

MONTH.	Monthly Ratio of Flow.	Computed Flow in Million Gals.	Monthly Ratio of Consumption.	Computed Consumption.	Surplus.	Deficiency.
January	1.60	132,480,000	0.97	80,316,000	52,164,000	....
February	1.25	103,500,000	0.94	77,832,000	25,668,000	....
March	1.15	95,220,000	0.99	81,972,000	13,248,000	....
April	1.20	99,360,000	0.96	79,488,000	19,872,000	....
May	1.00	82,800,000	0.98	81,144,000	1,656,000	....
June	0.75	62,100,000	1.08	89,424,000	....	27,324,000
July	0.55	45,540,000	1.15	95,220,000	....	49,680,000
August	0.50	41,400,000	1.20	99,360,000	....	57,960,000
September	0.75	62,100,000	0.89	73,692,000	....	10,592,000
October	0.75	62,100,000	0.98	81,144,000	....	19,044,000
November	1.50	124,200,000	0.89	73,692,000	50,508,000	....
December	1.00	82,800,000	0.97	80,316,000	2,484,000	....
Total	12.00	993,600,000	12.00	993,600,000	165,600,000	164,600,000
Average	1.00	82,800,000	1.00	82,800,000	....	....

An examination of the natural facilities for storage shows that the necessary room is wanting.

A survey made for a storage pond, to be created by damming the creek near the river, shows that but 33,500,000 gallons could be stored without an extravagant outlay for retaining dams. This is from the circumstance that the lower part of Lamberton Creek runs through a narrow gorge or ravine but a few hundred feet wide.

This amount of storage room would barely suffice for our present needs, leaving out of view the future. Thus, suppose the summer flow of Lamberton Creek for the months of July and August to be per day 1,200,000 gallons, or about the flow noted during the last week in August, or say 72,000,000 gallons, and take the consumption at 1,720,000 gallons per day, or about 33 per cent. more than was pumped last year, say 103,200,000. It would then be necessary to have in store at the commencement of the dry period 31,200,000 gallons, or nearly the entire capacity of our pond.

The necessary storage could, however, be obtained by placing the dam near the upper road, and raising the water above the present surface of Lamberton Lake, but this would involve a considerable diminution of the drainage area, reducing the annual yield a corresponding amount.

A storage pond thus created would have a large proportion of shallow flowage, which would operate very unfavorably upon the quality of contained water.

It appears, therefore, from what has been said, that Lamberton Creek would furnish less than three million gallons per day if storage room could be provided sufficient, and as this storage room is wanting, it is apparent that only a much smaller amount could be depended upon, probably less than two million gallons per day, an amount far too small to warrant its adoption as a source of supply.

From what has been shown in regard to Lamberton Creek, but little need be said in relation to the lake itself. However, so highly has it been regarded by many of our citizens as a future source, that a few facts concerning it may not be without interest.

The lake is situated upon the stream which originates in Button Lake, and may be regarded as an enlargement of or basin upon the stream. Its superficial area is estimated at 34.74 acres, or about one acre less than Fisk's Lake. Its mid depth is about eighteen feet, and a large proportion of its area is less than ten feet; its cubical contents are roughly estimated, from the measures of depth and area which were taken, at 81,500,000 gallons. The source of this lake, as of all others, may be stated as that particular area which, receiving the annual rainfall, drains the same into and through the lake in question.

It is not an uncommon opinion that, by increasing the draft from this lake, and thereby lowering its surface, an increase in the annual flow from the lake could be effected. This could happen only if such lowering had the effect of directing a part of the underground water towards the lake which now flows away from it into some other outlet; that is, of increasing the extent of surface area which catches the rain and drains it into the lake and its feeders.

I know of no reason for supposing that such an effect would be produced.

The first effect of lowering the lake surface would undoubtedly result in increased flow, but this would be temporary, and would cease as soon as the ground water had reached its new level, and its equilibrium become restored.

QUALITY.

An examination of the report of the chemist will show that this source offers no particular inducement in point of quality, and that it possesses the same general characteristics of the other waters examined, so far as dissolved organic matter is concerned. It is true that some of the springs around Lamberton Lake are beautifully clear and cool, but their volume is so small when compared with the annual yield of the creek that their influence would be hardly perceptible.

An examination of the surface drained will aid us in an opinion of the quality, also.

Of the total drainage area of Lamberton Creek, there are, approximately, as follows:

Of Sandy Soil	51.0	per cent.
" Clay "	34.4	"
" Swamps	12.6	"
" Water	2.0	"
Total	100.0	per cent.

As regards timbered and cleared lands, there are of forest or wooded land 14 per cent., of cleared land 86 per cent.; and of cultivated land 71 per cent., uncultivated land 29 per cent.

The population upon the drainage area of Lamberton Creek is 180, or 28 persons per square mile—a number too small to raise a suspicion of sewage pollution.

After considerable rains, the waters of the Creek are turbid, and probably as uninviting as any source which has been suggested.

COLDBROOK CREEK, AND LAKES SUPPLYING THE SAME.

Coldbrook Creek enters the city on the east, and, flowing through the valley traversed by the D., G. H. & M. Railway, is diverted into the settling basin for immediate use. It has, in wet seasons, three branches or sources, the north branch following the valley occupied by the railway above mentioned.

The soil in the vicinity is of a sandy character, and hence this branch partakes of the character of a spring creek.

Its least flow is about 750,000 gallons per day, probably a little less, and, as its valley furnishes no sites for storage, owing mainly to the track of the railroad, no further attention need be paid to this source.

The outlet from Reed's and Fisk's Lakes unites with the north branch near the east line of the city, receiving on its way the waters which outlet through a small stream from the Church and Muir Lakes, which are about three-quarters of a mile north of Reed's Lake. An attempt has been made to divert the waters from these lakes into Reed's Lake by a cut-off, although at present a considerable amount of water is passing by the natural channel into the Reed's Lake stream.

QUANTITY.

In speaking of the quantity that may be derived from the Coldbrook source, I shall confine myself to the Reed's Lake and Church Lake streams, omitting the north branch, which follows the line of the railway, for the reason that no facilities exist for impounding the waters.

The drainage area of the portion considered, which embraces Reed's Lake and the Saddle-bag swamp, is estimated at 9.3 square miles, of which 2.1 square miles, or over 20 per cent., is swamp and water surface. I think we have in this abundant reason for the fact that the Reed's Lake stream is often dry for months at a time, owing to the great evaporation going on from these areas.*

Estimating that the drainage area will furnish in a dry year an average of 428,500 gallons per day per square mile, we have 3,985,000 gallons per day as the average from this source. But this cannot be realized without abundant facilities for storage. At least 550,000,000 gallons would have to be impounded at the beginning of a dry season, and probably much more.

This can be illustrated. During last season the Reed's Lake stream was entirely dry for, I think, longer than seventy days.

Suppose the daily draft from a storage pond to be 4,000,000 gallons per day, or a trifle more than the estimated daily average amount which this source can furnish. This would show that (4,000,000 x 70) 280,000,000 gallons would have to be in store at the beginning of the dry period, and if, at the end of the seventy days, the inlet failed to immediately equal the consumption, as it undoubtedly would, then considerably more storage area would be necessary.

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* As the water surface of Reed's Lake is included in the estimate above given, and as the evaporation from water surfaces is likely to much exceed the rainfall, the estimate of the amount of water collectible is somewhat too large.

In examining the valley of the creek, I find no suitable sites for the required storage. A survey for a pond reaching from East Bridge street to East Fulton street shows that only about 31,000,000 gallons could be stored, owing to the fact that the stream flows through a narrow gorge.

We may, therefore, dismiss this source from our consideration, for reasons similar to those existing at Lamberton Creek. First, the least annual yield is much too small for our future use, and, second, no facilities exist for storing the surplus waters of wet periods. With the storage which could be secured below Fulton street, less than 1,000,000 gallons per day could be secured.

Reed's Lake itself might be converted into a storage pond, but this would be open to serious objection.

First—The available water-shed would be greatly reduced, and with it the annual yield, which is already too small.

Second—By converting Reed's Lake into an impounding reservoir, its surface would be subjected to variations in level.

The area of Reed's Lake is about 275 acres, and to provide for impounding 500,000,000 gallons would require a distance of about six feet between high and low water levels. Lowering or raising the surface would be opposed by the owners of property adjoining, and for this and other obvious reasons, it would be necessary to acquire control of all the lands surrounding the lake, and its abolition as a place of summer resort.

QUALITY.

The quality of the Reed's Lake water is undesirable. The lake water illustrates the necessity of certain natural advantages which are here wanting. To be desirable as a source of water supply, a lake should have four prime requisites:

First—An abundant inflow and outflow, which will secure a good circulation.

Second—Abundant depth, which will aid in maintaining a low temperature in summer, and hinder and prevent organic and infusorial growth.

Third—A broad surface, which can be agitated by winds.

Fourth—Bold sandy or gravelly shores, which furnishes little foothold for aquatic plants.

So far does Reed's Lake come from meeting these conditions, that it may be regarded almost as a stagnant pool.

The inflow is less than evaporates from its surface in summer; it has a large extent of shallow flowage, and its shores are mainly filthy and uninviting from the vast quantity of organic substance and growth.

To raise or lower its surface would result in increasing the impurities now in the water.

I have met persons who believe that the Saddlebag swamps would, if tapped, furnish an abundant supply, but this is not so. Their area is included in the drainage area of Reed's Lake.

In ascending a stream, we find it decreasing in size as we approach its origin. These swamps are in the upper portion of the drainage ground of Coldbrook, and by themselves they could furnish but a small quantity of water.

As there is a point here about which many people seem to have vague opinions, I may, at the risk of repeating, be permitted to explain further. The roof of a house is a well-defined drainage area, the size of which can be estimated by any one. It receives the water falling upon it, and discharges the same by the gutter or conductor into the cistern, which corresponds to the storage pond.

Now, the drainage area of a creek, river or lake is just as real as that which feeds the cistern, only less apparent to the casual observer. It makes no difference how deep or extensive the cistern may be, it can only furnish the equivalent of the roof water.

The drainage area of the Saddle-bag swamps is not much larger than the swamp surface, and, although there might be in them a large amount of water, its removal would not be followed by any influx of water from underground regions. The amount of rain falling upon the surface drained, less the losses by evaporation and absorption by vegetation would be all that could be secured.

GREEN LAKE.

Green Lake is situated in the town of Leighton, Allegan county, thirteen miles south of the south line of the city, and four miles east of Division street. It has been regarded as a possible source of supply by gravity.

Mr. Stinson, the engineer of the Grand Rapids and Indiana Railroad, informs me that the track at Moline Station is about 195 feet higher than the track at the bridge at Ferry street.

Green Lake is 17 feet lower than the track at Moline, and from this data it appears that the lake is about 21 feet above the top water line in our distributing reservoir. This head would be insufficient to overcome the friction in a main of reasonable size, so that pumping would be necessary.

To cut through the ridge line which separates the valley of Grand River from the Green Lake valley would involve enormous expense, even if the level of the lake was much higher.

In regard to the amount of water which the lake could furnish, I am quite decidedly of the opinion, from my study of the maps and observations on the ground, that the quantity would be insufficient for our use in the near future.

In regard to the quality of the water, the examination shows nothing desirable, although the general appearance of the water at the time of my visit to the lake was much in its favor.

My conclusions as to this source are, that the quantity is insufficient, the quality undesirable, and that the cost of the work would be excessive.

INDIAN MILL CREEK.

Indian Mill Creek rises in the northwest corner of Alpine township, about seven miles northwesterly from the northwest corner of the city. It flows southerly and southeasterly, and discharges into the river at the D., G. H. & M. Railway bridge.

This stream has never been seriously considered as a possible source of water supply.

QUANTITY.

The drainage area of this stream above the point designed for the impounding dam, as estimated from the surveys which have been made of its water-shed, is 14.47 square miles. Assuming, as before, that each square mile can be depended on for an average of 428,500 gallons per day, or nine inches on the area drained, we have 6,200,395 gallons as the daily average that may be derived from this source.

The storage necessary to make this available cannot yet be accurately determined, but on the assumption that three and one-half inches within the water-shed will be sufficient, or 61,000,000 gallons per square mile, we have 882,670,000 gallons as the storage room required, or about 170 days' supply, assuming the minimum flow of the stream for the 170 days to be about 2,000,000 gallons per day.

It is quite possible that the estimate for storage is too small, but it would not be found so until the consumption had about reached the entire available yield of the stream. The stream is a "flashy" one, its flow reaching from four to five million gallons per day to possibly a hundred millions of gallons per day. On the 1st of April, 1880, it was running 6,500,000 gallons, and on May 11th 22,000,000 gallons, the last being three days after some heavy rains.

FACILITIES FOR STORAGE.

The impounding of the waters of Indian Mill Creek calls for natural facilities, and these are not wanting.

Preliminary surveys have been made of the valley a short distance west of the city, from which it appears that 500,000,000 gallons can be readily stored, and that, by raising the water so that its depth shall be what is in every way necessary and desirable for purposes of natural purification, the storage of 700,000,000 gallons can be effected, and that without unusual outlay.

QUALITY.

From what has been said relative to the quantity of water which can be derived from this source, it is important that the questions relative to the quality of the water receive a careful examination, and the inquiry should be directed not merely to the present or natural condition of the stream, but it should extend, if possible, to the quality of the water that would be provided from completed works.

As stated before, foreign substances in water may be classed as—

INORGANIC.

Generally harmless when free from poisonous metals.

VEGETABLE ORGANIC.

Not generally considered dangerous, but to be avoided, as liable, when undergoing decomposition, to render the water unwholesome.

ANIMAL ORGANIC.

Dangerous; exceedingly so when from sewage, cemetery drainage or manufacturing refuse.

The stream, as stated before, is a "flashy" one—that is, quick up and quick down, and its waters must be classed as surface waters. In dry weather the water is comparatively clear and colorless, but it is exceedingly turbid and uninviting after every considerable rain.

The report of the chemist shows that, as far as inorganic matters are concerned, the water is wholesome, but that the amount of organic matter is much greater than is desirable. An examination of the drainage area shows that no sources of sewage pollution exist. No manufacturing enterprises discharge their refuse into the stream.

The population on the drainage area is 556, or 38 per square mile, or one person on seventeen acres—a number too small to cause any suspicion of danger.

Moreover, it is possible to protect the stream in the future, and it is unlikely that the increase in population will ever be such as to involve danger from this source.*

It is safe to conclude that, substantially, all of the organic matters developed by the analyses are of vegetable origin.

The practical question, then, becomes: "Would the proposed impounding reservoir provide the conditions necessary to afford such clarification of the inlet water as would render it safe, wholesome, and desirable for domestic use?"

The impounding reservoir can be so constructed as to become a lake having substantially all the conditions necessary to insure clear, tasteless and colorless water. The depth would be such as would prevent the growth of aquatic plants over the bottom, and ensure a comparatively low temperature, which hinders the growth of microscopic animal and vegetable organisms.

The inlet and outlet waters would be of such volume as would secure a constant circulation.

The surface would be such as would afford ample play for the winds, being about four times the area of Lamberton Lake and ten times its capacity, while the shores could, without great expense, be made generally so abrupt, and be so protected with gravel, pavement or revetment as to preclude almost entirely the growth of animal and vegetable life along its borders.

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* The population of Alpine in 1870 was 1,445. The census just completed gives the population as 1,378.

The flood waters of the creek carry considerable suspended matter, and a large quantity of dissolved vegetable matter, or matter in solution, which gives the color, which is often very pronounced.

The suspended matters settle in a few hours. The soluble portions are much more persistent. Efforts to discharge the color by diffusing pure oxygen gas through samples of the water have not been attended with success. Evidence tending to show that the natural processes carried on in the lake would be all sufficient to secure the requisite degree of purity, is not quite satisfactory, for the reason that the precise conditions and circumstances of each case are not known.

A recent writer, in discussing the question, says: "Waters flowing in brooks from the wooded hills "and the swamps, almost always come down to the "lakes highly charged with the coloring matter and "substance of forest leaves and grasses, and not unfrequently have a very perceptible reddish or "chocolate hue. The waters are soon relieved of "these vegetable impurities by nature's process in "the lake, and their natural transparency and "sparkle is restored to them. Sunlight has been "credited with a strong influence in the removal of "color from water. The chemical transformation "already begun upon the hills is continued in the "lake, and the atmospheric oxygen aids in releasing "the gases of the minutely subdivided vegetable "products producing the color, when the mineral "residues have sufficient specific gravity to take "them speedily to the bottom. The winds are the "good physicians that bring the restoring remedies." (*Fanning's Water Supply Engineering, 1878.*)

"Chemistry would suggest, and it has been found "by experience, that discolored water becomes clear "again after an exposure to air of a few days or "weeks in basins or other places where new matter "cannot be taken up." (*Boston Report on Additional Supply, 1874.*)

Mr. Bateman, a celebrated hydraulic engineer of England, in evidence before the Royal Commission of 1867 on Water Supply, says: "Any color with "which the streams may occasionally be charged is "discharged on exposure in these large reservoirs, "or by subsidence. Loch Katrine, which is probably as fine a body of pure water as any in the "world, and is absolutely colorless, is fed by mountain streams which, in summer and in autumn, are "as brown as porter. I have never seen a darker "stream, even from a bog in Ireland, than the river "Strowen, which flows into Loch Katrine, and is "one of the principal contributors to it on the "northern side of the lake; but all the color is discharged by exposure to the atmosphere in so large "a surface, namely, 3,000 acres. That is also the "case in the Manchester water works, and in all "the other water works where the water is collected "in a large body; however colored it is in the first "instance, its impurities become removed by time "and exposure."

"So also the waters of brooks that feed Lake

"Cochituate mostly flow through meadow lands, "and are very highly colored in the late summer "and fall; yet before they leave the lake they become clear and almost colorless. Almost all rivers "flowing through a fertile country have, especially "in summer and autumn, a more or less earthy "taste, and a brownish-yellow color, which, to a "great extent, disappears by storage in large lakes." (*Report of Medical Commission*, *Boston*, *1874*.)

In the report above quoted from, I find the following relative to the Charles, Sudbury and Shawshine Rivers, which were under examination as proposed sources of additional supply for the city of Boston: "If no storage basins were proposed, none "of these river-waters could be recommended for domestic use, except, possibly, the Shawshine."

The population upon these rivers was, at that time, as follows:

Sudbury	229	per	square	mile.
Charles	165	"	"	"
Shawshine	79	"	"	"

Analyses of these waters gave the following results:

	Date.	Free Ammonia.	Alb. Ammonia.
Shawshine,	Sept. 22, 1874	.020	.12
Charles,	" 9, "	.026	.16
Sudbury,	" 5, "	.034	.36

Evidence was abundant that the organic matter in these waters was partly from sewage.

Dr. Lyon Playfair, professor of chemistry in the University of Edinburg, in his testimony before the commissioners on proper sources of supply for London, in 1867, states, in regard to organic matter in water: "If it be a mere vegetable matter, such as "comes from a peaty district, even if the water "originally is of a pale sherry color, on being ex-"posed to the air in reservoirs, or in canals leading "from one reservoir to another, the vegetable mat-"ter gets acted upon by the air, and becomes in-"soluble, and is chiefly deposited, and what remains "has no influence on health."

The following, from a report of the Cochituate Water Board on additional supply (1874), relates to actual experience with waters colored with organic impurities: "In July and August the Sudbury "water was entering Lake Cochituate at the rate of "from twenty to thirty millions of gallons per day, "and, in addition, a large supply was received from "the streams naturally tributary to the lake, which "possessed an equal color with that of the Sudbury "water; yet, when these waters reached the pipes "for distribution, no color was noticeable, and the "slightly bitter taste which they originally had was "lost."

The following, from Humber's Water Supply Engineering, may be taken as illustrating English experience: "The water impounded for purposes of "town supplies is sometimes filtered before delivery, "but in many cases no further purification is deemed "necessary than that which the water undergoes in "the large reservoirs by the subsidence of the sus-"pended matters, and the atmospheric oxidation of "some of the organic impurities which may have "been brought down from the gathering-ground. "Water impounded from moorland is frequently "discolored by peat, but this discoloration in great "part vanishes in the reservoir. The area, and "capacity of, which storage reservoirs, as such, have "to be made, is generally in excess of that required "for efficient settlement, so that seldom, if ever, "will an addition have to be made to the capacity "of a storage reservoir, in order specially to allow "of the complete subsidence of suspended matter."

Enough has been quoted to show what may be expected in a storage reservoir where the conditions are favorable for the precipitation and oxidation of impurities, and where new matters cannot be taken up.

There is a trouble inherent in the reservoir itself to which allusion has before been made, namely, the inception and growth of minute vegetable organisms, but as this is a trouble that all large reservoirs are liable to—one for which no adequate remedy is known, and one which need cause no apprehension, so far as the wholesomeness of the water is concerned, and which occurs only at long intervals, and is generally of short duration, no further consideration need be given it.

HARDNESS.

The waters of Indian Mill Creek are of a hardness much greater than desirable.

The examination made August 29, at which time the hardness was probably at its greatest, gave 14.45 degrees, of which 10.80 was temporary, and only 3.65 permanent.

I regard this fact as of importance, as indicating that the water may be made very desirable for domestic and manufacturing uses by the application of the lime-softening process.

The above figures, however, need not be taken as the ordinary measure of the hardness from the completed storage works as designed. The storm or flood waters are somewhat softer. It has also been found that very hard water exposed to atmospheric influences is gradually softened, and, as the hardness of Indian Mill Creek water is largely temporary, it is probable that this effect might be considerable.

The temporary hardness is maintained by carbonic acid gas in the water, which enables it to hold in solution carbonate of lime; and when the water is exposed, as in a lake, carbonic acid gas escapes into the atmosphere, and carbonate of lime is precipitated. The experience of those who have used this water for steam and other purposes is favorable.

It remains to describe briefly the proposed works for the introduction of Indian Mill Creek water.

They consist of an artificial lake, to be made by extending a dam across the valley of the creek at a point about one-quarter of a mile north and west of the northwest corner of the limits of the city. From the lake a cast-iron conduit or supply main would be carried to the present pumping works, the main delivering into a receiving basin or pump well, from which it would be drawn by the pumps.

The storage lake proposed would have an area of about 135 acres, and a depth over the eastern portion of from twenty to twenty-five feet, and a capacity above low-water mark—that is, above the main outlet conduit—of about 375,000,000 gallons.

In the construction of the reservoir, the bottom and sides to be thoroughly cleared and carefully burned over, and all vegetable matter removed.

The mucky portions, where the water will be less than fifteen feet deep, to be covered with sand.

The shores to be so changed as to reduce the shallow flowage to the least possible amount, and entire circuit of the lake to be paved with cobblestones set in gravel, the paving to extend, where practicable, from high to low water line. The protection of the shores will add considerable to the expense, but the increased purity of the water will compensate for all that is done in this direction.

It will be seen that the proposed lake will have about four times the area of Lamberton Lake, and many times its capacity, and that, if well and thoroughly constructed, it will possess nearly all the essentials necessary to furnish pure and wholesome lake water, namely, good circulation, good depth, a broad surface, the length in the direction of the prevailing winds being about one mile, and clean, bold shores, which afford no foothold for aquatic plants.

GRAND RIVER.

In Grand River we find an inexhaustible supply. It is a fair presumption that the only reason why the river was not selected as a source of supply at the time the works were constructed in 1874 was one which had to do entirely with the quality of the water. I am told by the men who run logs on the river that the water is not used by them for drinking purposes.

There is among our citizens a strong prejudice against its use.

The analysis of the river water shows an amount of organic matter greater than is desirable. It is an admitted fact that sewage from the small towns along the river is and will be discharged into it. It has been claimed that running waters free themselves from noxious elements of sewage; that the dilution of sewage in large bodies of pure water and its subsequent oxidation render it innocuous.

It is claimed, on the other hand, that the noxious elements of sewage are not readily destroyed by dilution or oxidation, but that the specific thing which induces many transmissible diseases, as typhoid, cholera, etc., is an organized, vitalized body, capable of resisting for a long time those natural agencies which are relied on to effect its destruction.

The utterances of the Massachusetts State Board of Health are believed to furnish the latest and best authority upon the subject of the alleged self-purification of running streams. The following from their annual reports is submitted, as tending to show that, if a running stream is once dangerously polluted by sewage, the greatest caution should be exercised in relation to its use for purposes of supply:

"It is a wide-spread popular idea that, no matter "how much impurity is discharged into a running "stream, yet by flowing a dozen miles or so the "stream will, for all practical purposes, free itself "from the impurity, and become fit for use, even as "a source of water supply. It has been alleged that "the organic matter is almost completely oxidized "by the oxygen in the air, and by that dissolved in "the water, and that this oxidizing action is very "much increased if the water be agitated by passing "over weirs or natural falls.

"This feeling has gained considerable currency, "and has been held by some men who are looked to "as authorities, such as Dr. Miller, Dr. Odling and "Dr. Letheby. It is, however, unsupported by di-"rect proof; in fact, the experimental evidence "leads us to the contrary opinion.

"The Rivers Pollution Commission made this "question the subject of direct investigation, and "showed very conclusively that the commonly re-"ceived opinion was erroneous. They chose locali-"ties on several streams where the rivers, in each "instance, flowed for almost a dozen miles without "receiving additional pollution, and determined the "amount of organic matter destroyed. They also "made admixtures of ordinary sewage with different "quantities of water, and in these artificial mix- "tures, which were, by various devices, exposed to "the free action of the oxygen of the air, they de- "termined the rate at which the organic matter "disappeared. This they did by estimating, from "time to time, the organic nitrogen and carbon "contained in the solution; also, by observing the "rate at which the dissolved oxygen disappeared. "As a result of these experiments, they affirm that—

"'It is evident that, so far from sewage mixed "with twenty times its volume of water being oxi- "dized during a flow of ten or twelve miles, scarcely "two-thirds of it would be so destroyed in a flow of "one hundred and sixty-eight miles at the rate of "one mile per hour, or after the lapse of a week. "In fact, whether we examine the organic pollution "of a river at different points of its flow, or the rate "of disappearance of the organic matter of sewage "when the latter is mixed with fresh water and vio- "lently agitated in contact with air, or, finally, the "rate at which dissolved oxygen disappears in water "polluted with five per cent. of sewage, we are led, "in each case, to the inevitable conclusion that the "oxidation of organic matter in sewage proceeds "with extreme slowness, even when the sewage is "mixed with a large volume of unpolluted water, "and that it is impossible to say how far such water "must flow before the sewage matter becomes thor- "oughly oxidized. It will be safe to infer, however, "from the above results that there is no river in the "United Kingdom long enough to affect the destruc-

"tion of sewage by oxidation. These results confirm "the opinion arrived at from theoretical considera- "tions, and expressed by Sir Benjamin Brodie in his "evidence given before the former Rivers Pollution "Commission. (*First Report, River Thames, Vol.* "*II. Minutes of Evidence, page 49.*) His evidence "was to the following effect:

"'I should say that it is simply impossible that "the oxidizing power acting on sewage running in "mixture with water over a distance of any length "is sufficient to remove its noxious quality. I pre- "sume that the sewage can only come in contact "with oxygen from the oxygen contained in the "water, and also from the oxygen on the surface of "the water, and we are aware that ordinary oxygen "does not exercise any rapidly oxidizing power on "organic matter. I believe that an infinitesimally "small quantity of decaying matter is able to pro- "duce an injurious effect upon health. Therefore, "if a large proportion of organic matter was re- "moved by the process of oxidation, the quantity "left might be quite sufficient to be injurious to "health.

"'With regard to the oxidation, we know that, to "destroy organic matter, the most powerful oxidiz- "ing agents are required. We must boil it with "nitric acid and chloric acid, and the most perfect "chemical agents. To think to get rid of organic "matter by exposure to the air for a short time is "absurd.'

"It would seem from the experiments of the "Rivers Commission that, in a flow of a dozen or "twenty miles, as much as twenty or thirty per "cent. of ordinary sewage impurity might, in summer weather, be destroyed by oxidation. It must "be borne in mind, however, that, for all we know, "the portion remaining unoxidized may be the very "portion most injurious to health. If certain diseases be propagated by germs—by living organisms "—we may well suppose that such germs would "live, although dead organic matter might be destroyed. In expressing our own conclusions on "this subject, we, perhaps, cannot do better than "quote the words of Dr. Frankland, the most eminent chemical authority on the sewage question:

"'There is no process practicable on the large "scale by which that noxious material (sewage matter) can be removed from water once so contaminated, and, therefore, I am of the opinion that "water which has once been contaminated by sewage or manure matter is thenceforth unsuitable "for domestic use.'

"Too much stress cannot be laid upon the importance of preventing the discharge of such refuse, "and of sewage in its more restricted sense, into "any stream used or likely to be used as a source of "water supply.

"The importance of this matter is underrated for "two reasons: First, because of the oft-repeated "assertion, made on the authority of Dr. Letheby, "that, 'if sewage matter be mixed with twenty "times its bulk of ordinary river water, and flow a "dozen miles, there is not a particle of that sewage "to be discovered by chemical means.' Secondly, "because of the feeling that, to be in any way "prejudicial to health, a water must contain enough "animal matter to be recognized readily by chemi-"cal tests—enough, in fact, to be expressed in "figures. The first of these opinions has been dis-"proved by the experiments of the Rivers Commis-"sion in England, who have shown that not only is "a flow of twelve miles insufficient to destroy the "organic matter of sewage when mixed with water "in the above proportion, but also a flow of one "hundred and sixty miles is far from sufficient for "that purpose. When sewage is mixed with wa-"ter, some of its constituents begin to decompose "very soon.

"The urea, for example, is quickly converted into "carbonate of ammonium. Others of the constit-"uents, however, are less ready to begin to decom-"pose, and when decomposition does set in, although "some of the substances may undergo chemical "change, there still remain organic nitrogenous "compounds in the mixture, and these substances "are swept along by the rivers, even to the sea.

"The carcass of a dead animal thrown into a river "or into a pond, and confined there so as not to be "borne off bodily, gradually wastes away, and in "a longer or shorter time the main part of the car-"cass has disappeared. What has become of it? "A part has been converted into gaseous products "of decomposition, as the offensive odors observed "during the decay will testify, but another portion "has been carried off by the stream as soluble nitro-"genous organic matter. This nitrogenous matter "would be detected a short distance away with "greater or less ease, according to the volume of "water present, and in a stream of large size or in a "lake, at no very great distance from the source of "contamination, it would be impossible to discover "any offensive matter.

"There is a limit to the delicacy of our tests; "there is a point beyond which, at the present, "we are not able to go. At the present time a "chemical analysis alone is not sufficient to deter-"mine the desirability of a given water supply.

"The rice-water evacuations of a cholera patient "diluted with no very large amount of water would "form a liquid in which chemical tests would fail to "indicate the presence of anything which would be "pronounced injurious, and yet there is no destruc-"tion of poisonous material; it is still in the liquid, "although not to be recognized, and such water is "now regarded by physicians as the most direct and "certain vehicle for the transmission of Asiatic "cholera.

"The second opinion is, that sewage, if diluted to "a very considerable extent, becomes innocuous. "This opinion, which involves questions belonging "to the physician rather than to the chemist, is very "likely to be carried too far.

"I do not know that we have any proof that per-"fectly fresh sewage (the term being used in its "more restricted sense) coming from healthy per-"sons when mixed with water is injurious if drank. "It would probably not be asserted that such a "mixture was actually good to drink; it would cer-"tainly be opposed to our instinctive ideas. It is "true that fish are not destroyed by even a con-"siderable discharge of fresh sewage into a stream. "We do know, however, that sewage which has

" begun to undergo decomposition is unwholesome. " Such decomposing sewage has been observed to " destroy and drive away the fish from the stream in " the immediate neighborhood of the point of discharge; and there are a great number of instances " on record where cases of sickness have been traced " directly to the fact that the water used for drinking was rendered foul by the decomposing excremental matter which found its way into the source " of supply; and drinking water polluted by even an " infinitesimal amount of excremental matter coming from those suffering from typhoid fever is now " very generally held to be capable of propagating " that disease.

" It has already been stated that sewage matter " itself is not completely destroyed when it is introduced into a running stream, and is borne along " even for many miles. We must suppose, and, indeed, have every reason to believe, that in the " case of sewage which, when fresh, is capable of " communicating disease, the destruction of the peculiar organized matter which has the specific " effect must be more slow even than the unorganized effete matter which forms the mass of the " dissolved and suspended solid matter of ordinary " sewage. In the case of certain diseases, which " have been shown by experiment to owe their origin to the presence of distinct and recognized " living organisms, it has been found that these " organisms retain their vitality in spite of very " varied conditions, and through very considerable " changes of temperature.

" One would not assert that the drainage from a "single house would contaminate the water of a "large river like the Merrimac so as to make it unfit "for domestic use, yet we must beware how we "depreciate the effect of sewage matter, even in a "large stream.

"While with a small amount of sewage the chances "are as favorable as possible for the action of the "atmospheric influences, and the chances of taking "up any undecomposed particle of material capable "of propagating disease are rendered proportionally "small, owing to the great dilution, it is to be borne "in mind that the action of such matter on the "system is not regarded as cumulative. A minute "quantity may do much harm, because it is now "generally believed that it may hold the specific "thing which propagates specific diseases.

"In the case of certain organic poisons which "effect the system through the blood, the experi-"ments of M. Chaveau and of Dr. Burdon-Sanderson "on vaccine matter render it well-nigh certain that "no amount of dilution can destroy the power of "infection which these poisons possess. From these "experiments, it appears that if inoculation be per-"formed with vaccine lymph after it has been very "much diluted, the chance of the formation of pus-"tules is rendered less; but when the vaccination "is successful, the pustule formed presents its nor-"mal features, and passes through the usual stages "of development."

In the examination of Grand River, therefore, this question becomes of vital importance: "Is the river actually contaminated with sewage pollution? and if not, is it probable that it ever will be?"

The question has already attracted the attention of our State Board of Health. The President, R. C. Kedzie, M. D., in the annual address published in the report of 1878, says:

" The fear is expressed that, when the population "along the river above Detroit becomes greatly increased, the water of Detroit River will be unfit "for domestic and potable use. A similar trouble "may yet vex the people of Lansing. The Grand "River flows from Jackson through Lansing. This "stream receives a certain amount of sewage from "Jackson, and this polluting material is reinforced "as the stream flows past the State Prison, where "the night-buckets of all the prisoners are emptied "into a sewer, which at once discharges the excreta "of nearly 1,000 men into Grand River."

A knowledge of the density of population on different drainage areas may, in a general way, aid in forming a conclusion as to the amount of sewage pollution likely to find its way into the streams. A population collected in cities provided with water supply and sewerage will, evidently, pollute the waters far more than would the same population scattered over a wide territory. A knowledge of its distribution is, therefore, of importance as a means of comparison with other drainage areas.

The area enclosed by the water-shed of Grand River above this city is 4,831 square miles, and the population upon the same has been as follows:

In 1850	52,167
" 1860	119,316
" 1870	281,880

It is probably safe to assume that the population at present is about 400,000, or 83 per square mile.

The following table, compiled mainly from a report by D. M. Green, C. E., on a supply of water for the city of Troy, N. Y. (February, 1877), exhibits the relative density of population upon various drainage areas from which water supplies are drawn:

NAME OF SOURCE.		City Supplied.	Populat'n per sq. mile of drainage area
Thames		London	270
Sudbury,	At the time proposed for additional supply.	Boston	229
Charles,			165
Mystic,			610
Shawshine,			79
Croton		New York	65
Hempstead, and others		Brooklyn	119
Mohawk			106
Hudson, above Troy			36
“ below Mohawk			65
“ above Albany		Albany	77
“ “ Poughk'psie,		Hudson and Poughkeepsie	86
Passaic		Newark	132
Lamberton Creek			28
Indian Mill Creek			38
Hemlock Lake		Rochester	36

There are located on Grand River and its tributaries, within about forty miles of this city, villages as follows, with population as given:

	Population in 1870.
Rockford	582
Cedar Springs	600
Greenville	1,807
Lyons	704
Ionia	2,500
Saranac	724
Lowell	1,503
Ada	1,427
Portland	1,060
Hastings	1,793
Total	12,700

Suppose the population of these villages within this decade reaches 25,000, and, for the purpose of argument, it may be supposed that the entire drainage is daily discharged into the river, although the fact, probably, is that not ten per cent. is so discharged. Hence, if the 25,000 persons were all occupying premises provided with water-works and sewerage, the discharge from the sewers would approximate (25,000 x 60) 1,500,000 gallons per day; and, if the minimum flow of the river was very small, it would be hopelessly polluted by a much less amount than this, or even by the Intermediate Prison at Ionia.

Its volume, therefore, is an element to be considered, and its least volume will exhibit the greatest amount of sewage pollution, if any exists.

During the past season the flow of the river was measured when it was said to be nearly as low as had ever been known (although this may not have been exactly true). The first fairly accurate measurement of the flow was made October 1, 1879, the result being 613,000,000 gallons per day. An approximate gauging, made September 29, gave 675,000,000 gallons per day, while a careful measurement made October 14 under unusually favorable conditions, gave 696,400,000 gallons per day.

The water in this portion of the river averaged about seven feet deep.

The surface of the water October 14 was three inches higher than it was at the close of the prolonged drought in August, and the surface of the water October 1 was about two inches higher than at the lowest stage.

It is, therefore, likely that the least flow was about 600,000,000 gallons per day, or 0.19 cubic feet per second per square mile of drainage area.

The following table will exhibit the least flow of some streams which have been observed. It is taken mainly from Croes and Howell's report on additional supply for the city of Newark:

LEAST FLOW OF STREAMS.

AUTHORITY.	NAME.	Dr'nage Area. sq. miles.	Date.	Flow in cubic ft. per sec'nd per sq. mile.
T. G Ellis......	Connecticut ...	10,234.00	1876	0.51
C. Herschel....	Merrimac	4,136.00	1876	0.53
J. F. Smith....	Schuylkill......	1,800.00	1874	0.21
Croes & Howell.	Passaic	981.00	1878	0.23
J. J. R. Croes..	Croton.........	338.82	1833	0.15
C. Herschel....	Concord*	352.00	1876	0.17
C. D. Ward....	Hackensack....	84.00	1873	0.33
C. Herschel....	Sudbury*......	76.30	1876	0.05
J. J. R. Croes..	Croton,west br.*	20.37	1871	0.02
J. P. Kirkwood.	Thames, Eng...	3,676.00	1868	0.13

* Gaugings have not continued more than three years.

Suppose the consumption of water in the city reaches 6,000,000 gallons per day, or one-hundredth of the least flow of the river. Then, if the pollution was equal to the amount above supposed, one-hundredth part, or the sewage from 250 people, would be mixed with the daily supply.

But the suppositions made are suppositions merely. The small towns named are not, as far as I know, provided with sewers, and nearly all the sewage or liquid waste is destroyed in the earth, and never reaches the river at all.

The late James P. Kirkwood, who was consulting engineer of the State Board of Health, in discussing the question of sewage pollution, said (report of 1876):

" It cannot be said that all rivers receiving sewage
"in any degree are unfit for use; for, of the rivers
"from which water is freely drawn for human use,

"there are very few that are not exposed to pollu-"tions of one kind or another, even up to their "sources. There is no such thing as pure water, "even at the sources, nor anywhere except the "laboratory. Pure water, therefore, or good water, "in ordinary parlance, is understood by the engineer "to mean a potable, wholesome water, not insipid "like rain water, and not open to the reception of "that class of impurities which endanger the indi-"vidual health."

Referring to the water supply of London, he says: "The London water companies take their waters "from the river (Thames) at Hampton and King-"ston. The sewage of Windsor and Eton enter "the river some fifteen miles above these points; "and, although the banks of the streams, particu-"larly the eddies, are said to show marks of the "impurities which it receives above, its presence at "Hampton, where the water is taken for the city, "cannot be sensibly distinguished, or proven to "have communicated to the water any dangerous "qualities, under ordinary circumstances. For this "condition of things (as now understood) we are "indebted to the fact of the volume of sewage being "very small compared to the volume of water in the "river; the sewage so largely diluted as to have "become almost an unappreciable quantity. To "secure this dilution, that, if the river be a quiet, "slow-flowing stream, it might take ten to twenty "miles to secure the required mixing; but, if fast-"running, or pouring over dams and falls of water, "a much less distance would have the same effect."

At that time, with the results of the investigations in Europe before him, and, also, all the facts collected by the Board of Health during seven years of its existence, Mr. Kirkwood made the following statement:

"It was long thought that the sewage was de-"stroyed by running water, but now it is believed "by chemists to be all but indestructable there, and "to be rendered insensible and inert *only by being* "*mixed largely—thoroughly diluted, in other words,* "*with at least one hundred times its volume of good* "*water.*"

Take, now, our supposable case of the sewage from 25,000 persons being discharged into the river within the forty miles of the city, which is undoubtedly many times as much as actually will be discharged into it in many years, or 1,500,000 gallons per day. This is to be diluted with never less than 600,000,000 gallons of ordinary river water; that is, mixed with four hundred times its volume, or diluted to an extent four times greater than the amount believed by Mr. Kirkwood to be sufficient to render it inert, and twenty times as much as was believed sufficient by Dr. Letheby to accomplish, after the water has run a dozen miles or so, the same result.

Take the case of the Ionia Prison, the sewage from which is discharged through a pipe directly into the river. The officers of the prison inform me that accommodations are, or are to be, made for 624 prisoners, and that the sewage amounts to about 35,000 gallons per day, or nearly 60 gallons per head.

Suppose that the number, including the prison attendants, is increased to 1,000, and that the sewage amounts to 60,000 gallons per day. This, diluted with the low-water volume of Grand River, will be *one part of sewage in ten thousand*, which is *one hundred* times the amount of dilution believed by Mr. Kirkwood to be sufficient to render the sewage inert.

It may with considerable assurance, therefore, be affirmed that no appreciable amount of direct sewage pollution exists at present in the river at this point, or can exist for many years.

But there is another consideration that should not be lost sight of, and that is the liability of pollution from cultivated lands. There are many rivers whose drainage areas are partly in inaccessible mountain regions where the danger could not exist, but the valley of Grand River is all fertile, and likely to be covered by population largely engaged in agricultural pursuits.

It is possible that the river may be polluted in this way.

The second English Rivers Pollution Commission publish conclusions based on the examination of some two thousand samples of water claimed to be drinkable, condemning river-water because it is liable to contamination from *drainage of cultivated land*, towns and manufactories. They say that "the admixture of even a small quantity of infected "discharges (of persons suffering from cholera or "typhoid fever) with a *large volume* of drinking "water is sufficient for the propagation of these "diseases among persons using such water."

Dr. Folsom, of the Massachusetts State Board of Health, says:

"The most striking case illustrating this law is "one reported by Dr. E. D. Mapother, of Dublin. "Forty cases of typhoid fever occurred in a hospital "which received its supply from a river. The cause "was traced to some barracks *twenty-five miles* "*higher up*, from which typhoidal dejections had "been emptied through drains into the river."

While so large a part of the Grand River valley is thinly populated no real danger may exist from this source, yet it may be well to keep in mind the probable effect of a dense population, which may be living in the valley within forty or fifty years.

An English periodical records that, in the spring of 1876, "the piers of Vauxhall bridge were coated "with a covering of upward of a foot deep of soil, "brought down from the upper portion of the "Thames during one tide, and this minor instance "is but a slight indication of the enormous deposits "cast into our (British) rivers through the washing of the surface soil from the adjacent fields. "The water, before being drawn into the Thames "companies' reservoirs, was loaded, consequently, "with soil, manure, sewage, and every imaginary "abomination that newly ploughed and manured "fields and towns could supply."

Of course it would be folly to pretend that anything of this kind is likely to occur here for many years, but who shall say that such a condition may not occur within the next half-century? And in building works for the supply of water, involving large outlays of money, we should build for the good of those who are, in the future, to pay the debt.

As to the present quality of the water: The chemist's report shows that it invariably contains a much larger amount of nitrogenous substances than is desirable; that it carries ordinarily a considerable amount of visible suspended matter, some of which requires several days for complete subsidence; that it has a decided taste and color; that it is so turbid at times from heavy rains that ordinary type cannot be seen through a thickness of seven inches, and that some of the suspended particles are so minute that filtration through paper or sand fails to remove them.

The excess of vegetable organic matter may be ascribed, in part, to the fact that wide areas lying within the water-shed are covered with vast quantities of fallen decaying timber. The banks of the river are also, in many cases, well lined with debris from the logs that are annually floated.

These causes will naturally grow less from year to year as the country becomes more settled, the gradual lessening of one source of contamination involving, to some extent, the increase of another.

There can be no doubt but the most complete means of clarification should be adopted to make the water of the river acceptable, or in any way desirable.

The hardness of the river water is ordinarily excessive, and could not be lessened by the method of filtration proposed, while it might possibly be slightly increased.

I understand that the experience of those who have used the river water for steam purposes is very unfavorable, and that the water is regarded as highly objectionable for such purposes.

The methods of purification in common use are copies of natural methods. They are principally filtration, either natural or artificial, and subsidence and precipitation, or combinations of both.

Many rivers have deep deposits of sand and gravel along their shores, which furnish water often of great purity. When a basin, well or covered gallery is sunk or extended through, along or into such strata, a supply of water can be obtained depending in amount upon the porosity of the sand or other material lying between the gallery and the main body of water, the distance through which the water percolates, the infiltration area of the receiving gallery, and the difference in level between the water in the gallery or well and the water which supplies it.

A number of cities in this country and in Europe are thus supplied by natural infiltration. The general experience regarding this method may be thus stated:

"So far as known, the same result has been experienced in every case. The supply is very limited in quantity, is evidently more derived from the ground-water on the land side than from the river, and partakes of the character of water from shallow wells rather than that of purified river water." (*Croes and Howell's Newark Report, 1879.*)

When waters carrying matters in suspension are filtered through sand or gravel, the surface of the filtering medium soon becomes coated with a deposit which becomes more and more impervious. This will take place in a river bed through which water is percolating to feed an infiltration gallery; and unless the river current is so rapid as to remove the deposits of silt, or they are periodically removed by floods or freshets, the action of the gallery is likely to be unsatisfactory, so far as drawing water from the river is concerned.

An essential condition to the success of infiltration basins or galleries is, that the river bed or surface through which the water percolates should be *clean and porous.*

I have examined the river for several miles above the city with reference to the feasibility of an infiltration gallery, but without finding the conditions requisite for success.

Artificial filtration through beds of sand has long been practiced in England, France and Germany with success. Such beds are found to clear the waters of matter in suspension, such as particles of mineral substances, minute vegetable fibres and organisms, the spawn of fish, and, to a slight extent, of matters in solution.

This method of purification has been practiced in this country only a few years, Poughkeepsie, on the Hudson, being, in 1871, the first American city to adopt the filter-bed system of clarification.

This subject has been very thoroughly examined by Prof. W. Ripley Nichols, of Boston, whose conclusions are thus stated:

(1) "No material has yet been brought into practical use for artificial filtration on the large scale "except sand.

(2) "With our present knowledge, we have no "evidence that sand filtration can be regarded as an "efficient means of purification of *polluted* water, "although it may, if properly carried out, lessen the "liability of ill effects.

(3) "All visible suspended particles, and an appreciable proportion of organic matter actually in "solution, may be removed by properly conducted "filtration through sand.

(4) "For the present, at any rate, it will be best "to regard artificial filtration mainly as a means for "the removal of *suspended* matters, although, under "the management of a person of intelligence, education and experience, the simple sand-filter is capable of producing sensible improvement in respect "to the organic matter which is dissolved in the "water. In ordinary practice, however, it is quite "certain that sufficient care will not be taken to "secure such results; and, in view of what is actually "accomplished in existing works, it seems to be best "to regard the removal of color and unpleasant "taste as incidental, and likely to vary very much, "according to the condition of the filter. As the "public mind becomes educated in the matter, a "higher standard of efficiency may be exacted; but "for the present, it should not be held out to towns

"and Water Boards, as a result which will follow "filtration through sand, that a water which is "naturally strongly colored by vegetable extractive "matter will be rendered colorless in ordinary practice, although it is true that, starting with an "entirely new filter, the first portions of water filtered may be deprived of color, and such an experiment has often led into error.

(5) "It is not worth while to introduce a system "of sand filtration in the case of any town supply, "unless there is the willingness to make such outlay "for construction and maintenance as shall render "the scheme thorough and efficient." *(Nichols' Filtration of Potable Waters, 1879.)*

In the estimates which have been prepared, provision is made for the daily clarification of 3,000,000 gallons by means of one subsiding reservoir holding 6,000,000 gallons, three filter-beds, and one clear water reservoir, to hold 1,500,000 gallons. The estimates include cost of two low-pressure compound engines, each capable of raising 3,000,000 gallons into the proposed settling basin in twenty-four hours, and two additional boilers.

As the whole pumping system could be more cheaply and readily managed at one station, and as the engine house at the filter-beds can be easily made to accommodate the whole plant, the cost of removing the present pumping machinery is included.

The estimates for settling, filter-beds and clear water basin are for thorough and substantial work, and include suitable covering for the clear water basin.

The operation of the completed works would be as follows: The river water would be drawn through a suitable conduit to a pump-well, from which it would be lifted by the low-service pumps into the settling basin on the slightly elevated lands east of the river; from the settling basin the water would be drawn on to the filter-beds, the water, after filtration, passing down into the clear water basin, from which it will be drawn by the high-service engines (that is, the present machinery) and forced into the distribution. Suitable pipes and other fixtures to be provided for emptying any of the beds or basins, and for such other operations as are necessary.

The upper portions of the filter-bed walls will be nearly vertical, to lessen the difficulties from ice, and to avoid, if possible, all trouble from this source; provision will be made for surrounding each basin below the water-line with a line of hot water or steam-pipe, to be supplied from the boilers. I think this will avoid entirely the labor of keeping the ice-sheet free from the walls, and at a nominal cost.

As the idea of double pumping may seem unnecessary, the causes which suggest it may be stated.

Apparently, at first sight all that is necessary is to build the filtering-beds on the river level, that is, below low water, and from them convey the water to the present pumping works. This would be inexpedient with the present pumping machinery as located.

The surface of the low water in the river at the point designed for the river works is 14.60 feet below that point in the pumps where the water has to be forced by atmospheric pressure. To operate the filter-beds, their outlet must be at least one foot lower than low water in the river, and the friction on two miles of twenty-four inch pipe conveying water at a suitable rate would require about nine feet fall to balance it, and, hence, the vertical lift at the pumps would be nearly twenty-five feet, which is greater than is desirable. The delivery main and the filter-beds could also only deliver their full capacity when the pumps were in operation, and, hence, to derive the full benefit of the system, it would be necessary to pump continuously.

To make the filter-beds of such size as would enable them to deliver all the water required in twelve or fifteen hours per day would involve a large and unnecessary expense.

To lay a conduit from two feet below low water to the pump house would involve a continuous cutting of about seventeen feet for nearly two miles, a considerable part of which would be in rock, and under water.

To construct the filtration system below low water would involve raising the walls of the beds and basins to such height as would prevent their overflow from high water, while it would be very difficult to clean out the deposits in the settling basins.

The construction of the works below the bed of the river would be much more expensive, and their operation and maintenance much more unsatisfactory, than if located a short distance east of the river, as designed.

THE ECONOMIC VALUE OF SOFT WATER.

It is generally known that hard waters are unsuitable for purposes requiring the use of soap, for use in steam boilers, and for many manufacturing operations.

In the use of hard water for steam purposes, scale is rapidly formed, which endangers the safety of the boiler, and materially shortens the time during which it can be used. The scale is a good non-conductor of heat, and, hence, extra amounts of fuel must be used, and consequently the expense of the same is proportionately increased.

In the use of hard water for washing purposes, a certain amount of soap is neutralized before useful effect is produced. Each grain of lime per imperial gallon destroys ten grains of pure soap, and this furnishes a measure of comparative value. Thus, an imperial gallon of water of ten degrees of hardness destroys one hundred grains of soap before a lather can be formed.

It is estimated that four imperial gallons is the smallest amount of water used per individual for all washing purposes, and that where baths are common sixteen gallons are thus daily used. (*Parkes' Hygiene.*)

Suppose, now, that this city had a population of

40,000, and that the daily amount of water used for washing purposes requiring soap was 80,000 imperial gallons, or only one-half as much as competent authorities declare as the smallest amount which is used, and that the hardness of the water was ten degrees. Then 100 grains of soap per gallon would be neutralized, and $\left(\frac{100 \times 2 \times 40,000}{7,000}\right)$ 1143 pounds of soap would represent the daily loss. This at 8 cents per pound, which is a fair price for the purest soaps, would amount to $91.44 cents per day, and $33,375.60 per year.

Writers upon this subject say that the wear and tear upon clothing washed with hard water amounts to as much as the loss in soap.

At the Bolton Union work-house, England, about $5 per week was saved in soap alone by changing from a water of five to a water of two degrees of hardness.

It was estimated in 1868 that the people of the city of Providence, R. I., would save annually $42,000 by substituting river water for well water.

It cannot be questioned that the annual loss to a city provided with water of excessive hardness is very great; that its use is followed by great inconvenience and waste; that much expense is incurred in the construction of cisterns, pumps and other arrangements to secure supplies of soft water, expense amounting in the aggregate to large sums; and that important manufactories cannot be successfully conducted where supplies of soft water are wanting.

DR. CLARK'S PROCESS FOR SOFTENING HARD WATERS.

This process was devised by Dr. Clark, of the University of Aberdeen, and first published in 1841.

When the hardness in water is due to the bi-carbonates of lime and magnesia, the water is softened by boiling, and practically the same effect may be brought about by the proper addition of lime. The lime unites with the bi-carbonates to form simple carbonates, which are deposited as a white powder. At the same time the suspended matters which the water may have contained are, in a great measure, removed, and also a large proportion of organic matter in solution.

Water softened by Clark's process is remarkably clear and transparent, and when seen in mass presents the beautiful blue tint so suggestive of purity.

Tested by the electric light process of Prof. Tyndall, the waters of the famous Loch Katrine appear like a muddy pool when compared with the unyielding transparency of the softened water of the Caterham water works.*

To apply the process, clear lime water is prepared in suitable tanks, and then mixed with the hard water which is to be softened by running both by properly proportioned streams into depositing basins. After standing a few hours in the depositing basins, the settling process is so far advanced that the clear water may be drawn from the surface for use.

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* Since this report was written, I have received a note from J. R. Downes, manager of the Caterham Water Company, in which he states that the works for softening have been in operation since 1862. The softened water is very satisfactory for steam purposes, and especially so from a sanitary standpoint. The works are entirely successful, and none have failed. New works are, from time to time, being constructed. The cost for lime and labor is $10 per million imperial gallons, or $8.34 per million American gallons.

The only objection to the process which is a real objection is that relating to the cost, but this is many times compensated for by the value of the purified and softened water. The cost is stated to be small, and that 1,000,000 imperial gallons with a temporary hardness of 14 degrees can be softened at a cost for lime and labor of about 23 English shillings, or $4.60 per 1,000,000 American gallons. (*Lippincott's Encyclopedia of Chemistry, 1879.*)

Dr. Frankland stated before the Commission on the London Water Bill that in several places where entire water supplies were softened, the cost for lime was $3.00 per million imperial gallons, or $2.50 per million American gallons.

It is likely that the cost here would much exceed the above figures, which make no account of interest on the original outlay; still the cost of softening may be stated as but a small part of the total amount which represents the actual cost of the water to the community.

Waters containing a large amount of organic matter or matters in suspension, require a much longer time for the operation of settling than do organically pure waters; hence the process should be supplemented by the ordinary methods of purification whenever the water to be softened is at all turbid or contains much organic matter.

The system is in active operation at the Chiltern

Hills Water Works, at Caterham, Canterbury, Bushby and other places. In no instance, however, is the operation carried on upon a scale as large as would be necessary here.

In regard to this, however, Prof. W. Ripley Nichols, who may be regarded as the first American authority upon potable waters, says: "*There is no* "*serious difficulty in applying this process on a very* "*large scale.*"

Mr. Thum has made a number of experiments in this connection, and his note in relation to them will be found in the Appendix, in which he says: "It is evident, that by the application of Clark's "process, the city may obtain a pure and soft "water."

It is frequently asked, Is it possible for us to obtain a water that is in every way desirable?

The experiments made by Mr. Thum warrant him in saying that it is possible.

Prof. Nichols assures us that there is no serious difficulty in the way of the application of Clark's process on a very large scale.

Standing far above the economic phases of this question is the question of purity. Mr. Thum states that the softened waters of Indian Mill Creek have of albuminoid ammonia only one-half as much as the natural water, and that the sediment deposited during the lime process, which in water free from organic matter would be white, is much colored by the organic matters thrown down, reducing the albuminoid ammonia to an amount smaller than is found in most of our American water supplies. In other words, the lime softening process reduces the amount of organic matter in the water about one-half, and to a point where the water may be called organically very pure. If it is possible, as suggested by the examinations and experiments made, to secure a water of only 4 degrees hardness, and which shall be without a trace of color or a suspicion of taste; containing no more organic matter than is found in the waters of Lake Michigan, or the Niagara; that is to say, a water the quality of which would probably be unexcelled by that of few, if any, cities in the United States; is it not advisable that all requisite steps should be taken which would lead to so desirable a result? Probably in no way could our industrial enterprises be so encouraged, the sanitary condition of our city so improved, and the health and comfort of our citizens so well assured as by the introduction of a supply of soft, pure water.

COMPARISON OF PROPOSED SOURCES.

In the estimates on Indian Mill Creek which are submitted, provision has been made for the construction of an artificial lake for impounding and purifying the water, with the expectation that a daily average of 6,000,000 gallons can be provided. It is expected that the quality of the water will be generally much superior to the natural waters of the creek, the favorable results being brought about by natural influences in the lake. I am of the opinion that the water thus provided will be clear, and generally without much color or taste, wholesome and safe in use. That it will be hard there can be no doubt, although it will probably be less objectionable in this regard than the water from the river, and less than the general average of the stream.

The estimates prepared for Grand River contemplate the most complete sand filtration, as the general character of the water is such that nothing short of this would accomplish a desirable result.

The sand filtration, if properly managed, will remove the suspended matters, but it must not be relied on to remove any color or unpleasant taste which the water may have, and but a small proportion of the dissolved organic matters, while the hardness, which is generally excessive, will remain substantially unchanged.

A certain degree of suspicion will always be entertained by many of our people in regard to the quality of the river water, while its color, taste and excessive hardness will operate against its general use, upon which everything relating to the success of the works depends.

In regard to matters of cost, it should be remembered that it is the annual interest and maintenance account that are to be considered, because this is the measure of the cost, or the annual tax which must be met.

The river estimates, based on a daily supply of 3,000,000 gallons, including the cost of the force main as far as the site of the pumping station on Canal street, give, as the cost of furnishing 1,000,000 gallons......................	$ 20.72
The estimated cost of furnishing Indian Mill Creek water per million gallons, when 6,000,000 gallons per day are used.	8.89
And when 3,000,000 per day are used.....	17.78

The actual cost per million gallons of our present supply is as follows:

Annual interest on water bonds outstanding, $382,000 at 8 per cent............	$30,560.00
Annual maintenance and operation last year	9,417.11
Cost of furnishing 404,000,000 gallons..	$39,977.11
" " " 1,000,000 " ..	98.95

The cost of a new supply would be represented by a larger interest account and a larger account for maintenance than is shown above.

Suppose works for additional supply cost $350,000, and furnish 3,000,000 gallons per day. Then we have as our future annual expense for water, not including the additional outlay for extension of mains that may be necessary before the consumption reaches the 3,000,000 gallons per day:

Interest on $382,000 at 8 per cent	$30,560.00
" " $350,000 at 6 " " *	21,000.00
Take as an item for purification	7,000.00
Pumping	16,425.00
Superintendent and office expenses, etc.	4,000.00
Cost of furnishing 1,095,000,000 gallons	$78,985.00
" " " 1,000,000 "	72.13

In this estimate is included an item for purification amounting to $6.39 per million gallons.

Thus we may expend an additional $350,000 for a new supply, and expend $6.39 per million gallons for purification, and then as soon as the consumption reaches the daily average of 3,000,000 gallons, the cost of the water per gallon would be considerably less than was actually paid during the past year.

The construction of works for additional supply would, however, result at first in an increased tax, as the consumption would not reach the maximum of 3,000,000 gallons for a considerable period, and, hence, will be seen the importance of securing such water as will result in the largest and most general use. If such general use be secured, then the water

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* I have good authority for the statement that water loan bonds bearing 5 per cent. interest could be readily sold at par.

revenue will soon be sufficient to provide payment for all annual expenses, and the community be really subjected to no greater expenses than at present, as that which is now used in the construction and purchase of equipments for private supplies of water will be diverted into the public treasury.

As an example of the financial success which follows the general use of public water, the city of Lynn, Mass., may be cited. The population is 35,000; cost of the works, $1,001,820.29; water debt, $921,500.00. The water revenue the past year was $73,791.47, which was sufficient to pay the annual expenses of maintaining and operating the works, the entire interest on the debt, and still leave $12,749.09 to account of the water debt sinking fund. It is estimated that 61 per cent. of the entire population are supplied from the city mains.

At first sight it might appear that the water takers in Lynn are heavily taxed, but this is in appearance rather than in reality, the water rates averaging but a fraction more than the rates here, while the family rate is much less. During the past year the amount of revenue received for each service in this city averaged $18.94, while the amount paid per service in Lynn was $17.88. If an accurate estimate could be made of the annual expense which is incurred by our citizens in the aggregate for the construction and maintenance of wells and cisterns, the purchase of pumps, pipes, conductors, filters and other appurtenances for the procurement of supplies of water, it is quite probable that it would appear that we paid proportionately as much as do the people of Lynn, while the difference in the value of the results derived is incalculably great.

It remains for me to express my thanks to my assistants, H. A. Collar and G. A. Christ, who have, unassisted, done all of the field work, and made many of the calculations necessary in the preparation of this report and the accompanying plans.

I am also under especial obligations to Hugo Thum, Ph. C., for his very valuable report annexed, and also for many important suggestions.

My thanks are also due the several members of the Board of Public Works for their cordial cooperation.

Respectfully submitted.

A. C. SEKELL,

City Surveyor.

GRAND RAPIDS, MICHIGAN, June 30, 1880.

APPENDIX.

GRAND RIVER.

Approximate Estimate for Furnishing 3,000,000 Gallons of Filtered Water per Day.

(1)

INLET CRIB AND CONDUIT TO PUMP WELL.

Crib work in river	$ 400.00
200 ft. wrought iron pipe, 24-inch, at 4.50	900.00
880 ft. brick conduit, at 4.00	3,520.00
	$4,820.00

(2)

Engine house, foundations and pump well	$25,000.00

(3)

Two 3,000,000-gallon pumping engines and boilers complete	$10,500.00

(4)

FILTER-BEDS, BASINS AND CONNECTIONS.

28,000	cubic yards	embankment, at .10	$ 2,800.00
45,000	“ “	excavation, at .30	13,500.00
10,911	“ “	puddle, at 1.50	16,366.50
2,701	“ “	concrete, at 6.50	17,556.50
2,701	“ “	cobble in cement, at 5.50	14,855.50
1,767	“ “	rubble in cement, at 6.50	11,485.54
623	square “	cobble pavement, at .60	373.80
2,422	linear feet	stone coping, at .75	1,816.50

105,000 brick, at 14.00	1,470.00
4,680 feet drain and air pipe, at .50	2,340.00
3,340 cubic yards sand, at .75	2,505.00
2,505 " " screened gravel, at 1.25	3,131.25
4,175 " " broken stone, at 2.50	10,437.50
2,160 feet 16-inch cast iron pipe, at 3.00	6,480.00
1,620 " 20-inch " " " at 3.50	5,670.00
Gate houses	1,000.00
Cut stone in effluent chambers	750.00
Screens	300.00
Special castings, valves and fixtures	3,600.00
Roof on clear water basin	10,000.00
(5)	$126,438.09

FORCING MAIN.

9,500 feet 24-inch cast iron pipe to Coldbrook street, at 5.25	$49,875.00

SUMMARY.

(1)	Inlet crib and conduit	$ 4,820.00
(2)	Engine house, foundations and pump well	25,000.00
(3)	Pumping engines and boilers	10,500.00
(4)	Filter-beds, basins and connections	126,438.09
(5)	Forcing main	49,875.00
(6)	Land and land damage	5,000.00
(7)	Fencing	400.00
(8)	Removing pumping machinery to new site	6,000.00
(9)	Engineering	8,000.00
(10)	Omissions and contingencies, 10 per cent	23,603.09
	Total	$259,636.18

Annual interest on $259,636.18 at 6 per cent	$ 15,578.17
Annual cost of maintaining filters	3,285.00
" " " low-service pumping	3,832.50
Cost of delivering 1,095,000,000 gallons	$ 22,695.67
" " " 1,000,000 "	20.72

INDIAN MILL CREEK.

APPROXIMATE ESTIMATE.

(1)

Land and water damages	$ 25,000.00

(2)

IMPOUNDING RESERVOIR, EXCLUSIVE OF DAM.

Changing line of highway	$ 3,000.00
Grubbing and clearing	2,000.00
Removing sod and sanding surface	8,000.00
14,600 cubic yards gravel, at .50	7,300.00
43,700 square yards cobble paving on slopes, at .50	21,850.00
Fencing	750.00
Total	$ 42,900.00

(3)

DAM, WASTE WEIR AND APPURTENANCES.

41,500	cubic yards	excavation, at .20	$ 8,300.00
146,000	" "	embankment, at .25	36,500.00
18,200	" "	puddle, at 1.25	22,750.00
5,700	" "	gravel, at .50	2,850.00
3,800	" "	dry rubble, at 3.00	11,400.00

3,262 cubic yards coursed rubble, ashlar faced, 12.00	39,144.00
800 cubic yards concrete, at 6.50	5,200.00
1,300 linear feet stone coping, at .75	975.00
Flash boards and fixtures	200.00
Sluice gates	200.00
Gate house, effluent chamber and outlet culvert	5,500.00
Total	$133,019.00

(4)

CONDUIT.

14,240 feet 24-inch cast iron pipe, at 5.25	$ 74,760.00
Extra for crossing river	7,500.00
Valves and special castings	2,000.00
Blow-off and air valves	200.00
Pump well	1,200.00
Screens	300.00
Total	$ 85,960.00

SUMMARY.

(1) Land and water damages	$ 25,000.00
(2) Impounding reservoir, exclusive of dam	42,900.00
(3) Dam and waste weir	133,019.00
(4) Conduit	85,960.00
(5) Engineering	8,000.00
(6) Omissions and contingencies, 10 per cent	29,487.90
Total	$324,366.90

Annual interest at 6 per cent	$ 19,462.01
Cost of delivering 2,190,000,000 gallons	19,462.01
" " " 1,000,000 "	8.89

REPORT OF CHEMIST.

GRAND RAPIDS, MICHIGAN, May 15, 1880.

A. C. SEKELL, *City Surveyor:*

SIR:—In submitting the results of my work on the samples of water taken from sources suggested as available for an additional supply for the city, I must state that my time was too limited to make a complete chemical, or even physical, examination, and that I have, therefore, confined myself to the observance of such facts and the estimation of such substances as are considered by the best authorities as most essential to indicate the quality of the water for domestic and economical uses.

Since the quality of a drinking water depends upon the amount and nature of the organic matter it contains, it is of primary importance to obtain as much knowledge in regard to the nature and amount of this organic matter as is possible, and we must look to chemistry for a great portion of this knowledge.

It is a general opinion that a chemist can pronounce in all cases with *definiteness of statement*, from the results of his analyses, whether a water is wholesome or not. This idea is correct only in cases of gross pollution. *In by far the greater number of cases he cannot definitely decide*, and this cannot be expected of the chemist or any other person. The chemist cannot definitely determine the amount of organic matter, and while medical authorities differ, as they do, as to the effects of this organic matter, the knowledge of the exact quantity in a given water will, in most cases, enable no person to state absolutely whether the water is injurious or not. Yet, although the present state of chemical and sanitary science will not furnish us with the power to make absolute and definite statements in regard to this impurity, chemistry detects its presence, approximates its amount, and is, in many instances, the best guide by which to judge of the quality of drinking water.

The method employed in estimating the organic matter in the following analyses is Wanklyn and Chapman's. It must be stated that this method, like all others devised for this purpose, does not give us as definite results as are desirable. It gives little indication as to the nature of the organic matter, whether it is animal or vegetable, yet it is by far superior to any other method, except, perhaps, that of Frankland and Armstrong, which, in the hands of a very skillful analyst, is said to give equally satisfactory results. An analysis by this method requires so much time, such costly apparatus and so much skill in manipulation that the process of Wanklyn and Chapman is much preferred.

The economic question—the suitability for use in steam boilers, for washing, dyeing, etc.—is answered definitely by the results of chemical examinations.

Chlorides and sulphates are present in the waters examined in such small amounts as to make their estimation unnecessary for this report.

As the character of any water is influenced by varying conditions, and varies from time to time, a series of examinations of each water should be made under different meteorological conditions, to aid in obtaining a satisfactory idea of the quality of the water.

For the purpose of the comparison of different waters which have the same general character and are in the same vicinity, it is best to collect samples of the different waters to be compared on the same day, so that the same conditions, rains or droughts, have exercised their influence on each sample alike.

During the examinations which have been made, these facts were considered and acted upon as much as possible.

Thirty-one samples of water have been examined, among which were five samples of hydrant water, for the purpose of comparison.

There were examined specimens as follows:

From	Grand River	5
"	Indian Mill Creek	6
"	Coldbrook Creek	2
"	City Mains	5
"	Carrier Creek	2
"	Lamberton Lake	2
"	Lamberton Creek	2
"	Lake Wabasis	3
"	Green Lake	2
"	Reed's Lake	1
"	Rouge River	1

GRAND RIVER.

Sample No. 1.—Collected August 25, 1879, from point in mid-channel about two miles above the city. Odor, peculiar, not very strong; taste, at 80 degrees C. resembling cistern water somewhat; appearance to eye, somewhat permeated by flocculent matter, the coarsest of which subsides in a few hours, the finer particles remaining in suspension, requiring about four days to subside, leaving the water clear; color, a ten-inch column has a yellowish tinge; microscopic appearance, the greater portion of sediment is iron as ferric oxide, diatoms, infusoria, portions of vegetable matter and sand.

Chemical Examination. — Ammonia, free, .000 parts per million; ammonia, albuminoid, .425 parts per million; hardness, Clark's scale, 13 degrees.

Remarks.—The river men say that, on account of the prolonged hot and dry weather, the water in the river is about four inches lower than they have ever seen it.

Sample No. 2.—Collected above the chair factory November 7, 1879. Odor, less marked; taste, less marked than that of August 25; color, a ten-inch column is darker than a similar one of distilled water or hydrant water, but less colored than sample from Indian Mill Creek of same date; sediment, less than in sample of August 25.

Chemical Examination. — Ammonia, free, 0.25 parts per million; ammonia, albuminoid, 0.178 parts per million.

Remarks.—The volume of water in river greater than on August 25, from recent rains.

Sample No. 3.—Collected one-fourth mile above city limits November 16, 1879. Odor, strong, resembling moist fungi, stronger than that of Indian Mill Creek or hydrant water of same date; taste, not agreeable, and in accordance with odor; color, less colored than Indian Mill Creek or hydrant water of same date. It is slightly hazy—less so than Indian Mill Creek or hydrant water.

Chemical Examination.—Ammonia, free, .015 parts per million; ammonia, albuminoid, 0.20 parts per million.

Remarks.—A number of heavy rains had fallen previous to collection.

Sample No. 4.—Recent rains had caused considerable turbidity in most of the waters, so that a gauge was constructed with which this turbidity was measured. It consisted of a cylindrical glass tube, graduated in inches, one inch in diameter and fifteen inches in length. One extremity of the tube was closed by cementing to it a suitable piece of French plate glass. This apparatus was placed upon a newspaper printed with (Brevier) type, water was slowly introduced into the tube until the words became just indistinguishable when looking down through the column of water. The height of the column was then read off and recorded. Turbidity, type just distinguishable through a column 6¾ inches deep; sediment, brownish-gray, many large particles subsiding in a short time, the finer particles remaining in suspension for a long time. These particles are so minutely subdivided that filtration through paper or sand will not entirely remove them.

Sample No. 5.—December 24. Cold; no recent rains. Color, yellowish tint; sediment, considerable, composed mostly of silica.

Chemical Examination.—Ammonia, free, .02 parts per million; ammonia, albuminoid, .30 parts per million.

INDIAN MILL CREEK.

Sample No. 1—August 29, 1879. The weather previous to this date had been hot and dry. The water was at an exceptionally low stage.

Physical Examination.—Odor, odorless; taste, tasteless, flat, not sparkling, as water rich in carbonic acid; color, the water is somewhat turbid. A fifteen inch column has a slight yellowish tint, not so colored as Grand River water of August 25, or hydrant water drawn from mains to-day; sediment, small amount; microscopical appearance, the sediment contains many diatomacæ, vegetable matters and infusoria (parameciæ and vorticel linae), and iron.

Chemical Examination.—Ammonia, free, .025 parts per million; ammonia, albuminoid, .212 parts per million; total hardness, 14.3; permanent hardness, 3.65; temporary hardness, 10.7.

Sample No. 2.—September 5, 1879. Collected thirty hours after first rain following long period of dry weather. On account of this rain, the quantity of water flowing in the creek was considerably increased. Color, some deeper than Grand River water before rain; taste, same as before; odor, same as before; microscopical appearance, same as before, the only difference being in quantity of sediment, which has increased considerably; the suspended matter was separated by filtration, carefully dried at 100 degrees C. Its weight was about two grains per gallon.

Chemical Examination.—Ammonia, free, .025 parts per million; ammonia, albuminoid, .275 parts per million; hardness, 13.7 degrees.

Sample No. 3.—Collected November 6, 1879. Weather cold; no heavy rains immediately before collection.

Physical Examination.—Odor, odorless; taste, flat; color, more colored than Grand River or hydrant water of same date.

Chemical Examination.—Ammonia, free, .012 parts per million; ammonia, albuminoid, .225 parts per million.

Sample No. 4.—Collected November 16, 1879, after several heavy rains.

Physical Character.—Color, quite an extent deeper than Grand River or hydrant water of same date; transparency, slightly hazy, not quite so much as hydrant water and more than Grand River; sediment, November 19, a sediment of coarse brownish particles has subsided (a larger amount than from samples of Grand River and hydrant water of same date). The supernatent liquid at this date is more hazy than hydrant water, and a little less than Grand River water; odor and taste, similar to hydrant water of same date.

Chemical Examination.— Ammonia, free, .020 parts per million; ammonia, albuminoid, .325 parts per million.

Sample No. 5.—Collected December 2, 1879, after continued and heavy rains.

Physical Examination.—Color, much deeper than either Reed's Lake or Carrier Creek waters of same date; transparency, less than Reed's Lake or Carrier Creek; sediment, about same appearance and quantity as in sample November 16, of same color as that of Reed's Lake, and darker than that of Carrier Creek; taste, less marked than that of Reed's Lake, and more than Carrier Creek.

Chemical Examination.—Ammonia, free, .050 parts per million; ammonia, albuminoid, .325 parts per million.

Sample No. 6.—Collected December 24, 1879. Color, lighter than on December 2.

Ammonia, free, .022 parts per million; ammonia, albuminoid, .180 parts per million.

RECAPITULATION OF INDIAN MILL CREEK.

Physical Characteristics.—Odor, odorless, or nearly so; color, very little color in dry weather, considerable color in rainy weather; sediment, very little sediment in dry weather, while immediately after rain found to contain two grains of suspended matters per United States gallon; microscopic appearance, the sediment is composed of diatomaceæ, infusoria (param and vorticel), vegetable organic matter, mineral matter, including some iron.

Chemical Examinations.—Ammonia, in parts per million:

Date.	Free.	Albuminoid.
August 29,	.025	.212
September 5,	.025	.275
November 6,	.012	.225
" 16,	.020	.325
December 2,	.050	.325
" 24,	.022	.180

Hardness.—August 29, permanent, 3.65 degrees; temporary, 10.80 degrees; total, 14.45 degrees. September 5, 13.70 degrees.

Remarks.—Since boiling removes or deposits about 10 grains of mineral matter, about .8 of the boiler incrustations would be prevented by sufficiently heating the water before using it in the steam boiler.

COLDBROOK CREEK.

Sample No. 1.—Collected September 6, twenty-four hours after the first rain succeeding the summer drought.

Physical Character.—Transparency, considerably less turbid than the water of Indian Mill Creek yesterday; color, less colored than Indian Mill Creek of September 5, and more than same on August 29; sediment, of about same appearance to eye as that of Indian Mill Creek of yesterday; suspended matter, weighs two grains per U. S. gallon; microscopical examination, shows infusoria and diatomaceæ present, similar in structure to those of Indian Mill Creek of yesterday.

Chemical Examination. — Ammonia, free, .062 parts per million; ammonia, albuminoid, .225 parts per million; hardness, 15 degrees.

Sample No. 2.—Collected December 24. Weather cold, and not much rain. Color, more colored than sample No. 1 is now.

Ammonia, free, .025 parts per million; ammonia, albuminoid, 0.220 parts per million.

CARRIER CREEK.

Sample No. 1.—Collected December 2, after heavy rains. Color, as colorless as distilled water; much less colored than Reed's Lake or Indian Mill Creek of same date.

Ammonia, free, .062 parts per million; ammonia, albuminoid, .115 parts per million; hardness, 15 degrees.

Sample No. 2.—Collected December 24. Cold, and not much rain.

Chemical Examination.—Ammonia, free, trace; ammonia, albuminoid, .15 parts per million.

LAMBERTON LAKE.

December 11.—Rainy weather since December 2. Received to-day two samples of water, one taken from Lamberton Lake and one taken from Lamberton Creek. In these two samples there exists a great difference in regard to suspended matter, the water from the lake being free from any perceptible suspended matter, and as colorless as distilled water; the water from the creek, on the other hand, having so much matter in suspension that (Brevier) type cannot be read through a column of 1¼ inches.

Sample No. 1.—December 11, 1879. Color, colorless; suspended matter, a few thin flakes of a whitish color; odor, some odor, but slight; taste, a slight taste.

Chemical Examination.—Ammonia, free, .022 parts per million; ammonia, albuminoid, .287 parts per million.

Sample No. 2.—December 24, 1879. Cold, and not much rain. Color, odor, suspended matter and taste same as sample No. 1.

Chemical Examination.—Ammonia, free, .160 parts per million; ammonia, albuminoid, .275 parts per million.

LAMBERTON CREEK.

Sample No. 1.—December 11. Rainy weather since December 2.

Physical Characteristics.—Transparency, (Brevier) type indistinguishable through a column 1¼ inches deep, and just readable through a column 1 inch deep; sediment, brownish-gray, many large particles subsiding quickly, the finer particles remaining in suspension. Filtration through sand or paper removes but a small portion of this finely divided matter. When filtered through these materials, (Brevier) type becomes indistinguishable through a column which exceeds 1¾ inches; color, after filtering through sand several times, the water became transparent enough to perceive that its color was about similar to hydrant water of same date; odor and taste, same as that of Lamberton Lake.

Chemical Examination.—Ammonia, free, .017 parts per million; ammonia, albuminoid, .337 parts per million; hardness, 17 degrees.

Sample No. 2.—Collected December 24, 1879.

Physical Characteristics.—Color, colorless and transparent, similar to waters of Lamberton Lake, Carrier Creek and hydrant water of same date.

Chemical Examination.—Ammonia, free, .020 parts per million; ammonia, albuminoid, .187 parts per million.

Remarks.—I cannot conceive how a sample of water from the creek can contain so much smaller amount of albuminoid ammonia than does a sample from the lake collected the same day. In each case the determinations were made a second time, with results as at first.

LAKE WABASIS.

Samples collected December 31, 1879. Weather cold since December 24. The lake had but recently frozen over; ice was about five inches thick.

Sample No. 1.—Was taken from the inlet at the southwest side of the lake.

Physical Characteristics.—Color, the darkest sample examined; sediment, small amount; microscopic examination, developed thousands of infusoria, diatomaceæ, and also dead organic matter. Among the infusoria are arctinophyrs chætophyla armata, cymbella ehrenbergii, euchelys nodulosa. Among the vegetable products were cotton fibers and decomposing woody fiber.

Chemical Examination.—Ammonia, free, .060 parts per million; ammonia, albuminoid, .440 parts per million.

Sample No. 2.—Was taken from the main body of the lake.

Physical Characteristics.—Color, less than that of inlet; sediment, small amount; microscopical appearance, similar to that of inlet. Many daphniæ are swimming about.

Chemical Examination.—Ammonia, free, .060 parts per million; ammonia, albuminoid, .330 parts per million.

Sample No. 3.—From the outlet water of the lake.

Physical Characteristics.—Color, lighter than sample No. 2, from middle of lake; sediment, same as that of lake; appearance same as that of lake with more daphniæ.

Chemical Examination.—Ammonia, free, .060 parts per million; ammonia, albuminoid, .255 parts per million.

Remarks.—It will be seen, on comparing the quantities of albuminoid ammonia in these three samples, that the water which enters the lake contains more organic matter than that found in the middle of the lake, and considerable more than that found in the outlet water. Some authorities state that a portion of the organic matter in water is decomposed and destroyed by oxidation when the water is stored in deep reservoirs for a length of time. In this case, the lake may act as a storage reservoir, and produce this decrease of organic matter.

ROUGE RIVER.

Sample collected December 24, 1879. Weather cold.

Physical Characteristics.—Color, quite deep; odor, slight; taste, not refreshing; microscopical examination, develops infusoria, vegetable fiber and algæ.

Chemical Examination.—Ammonia, free, .037 parts per million; ammonia, albuminoid, .300 parts per million.

REED'S LAKE.

Sample collected December 2, 1879, after heavy rains.

Physical Characteristics.—Color, deeper than Carrier Creek and lighter than Indian Mill Creek of same date; taste, pond-like, and more marked than any sample yet examined; microscopical examination, develops considerable animal and vegetable life.

Chemical Examination.—Ammonia, free, .087 parts per million; ammonia, albuminoid, .375 parts per million; hardness, 9 degrees, Clark's scale.

HYDRANT WATER.

Sample No. 1.—November 7, 1879.

Physical Characteristics.—Color, slightly colored, less than Grand River or Indian Mill Creek of same date; sediment, no individual particles large enough to be distinguished. When viewed through partially obstructed light it has a slight milkiness.

Chemical Examination.—Ammonia, free, trace; ammonia, albuminoid, .112 parts per million.

Sample No. 2.—November 13, 1879. This examination was made to ascertain whether the heavy rains of November 11 and 12, which had rendered the hydrant water quite turbid with finely divided matter of a grayish color, had increased the amount of organic matter.

Physical Characteristics.—Before filtration (Brevier) type could not be read through a column of more than 2¼ inches in depth. Filtration through paper removes but a small portion of this sediment when the type can be read through a column of 5 inches. Slow filtration through sand clarifies it so that the column reaches 9 inches before the type becomes indistinguishable.

Chemical Examination.— Ammonia, free, .020 parts per million; ammonia, albuminoid, .225 parts per million.

Remarks.—The effect of the storm has been to double the amount of organic matter.

Sample No. 3.—November 16, 1879.

Physical Characteristics.—Appearance, slightly hazy; color, lighter than Grand River or Indian

Mill Creek of same date. To ascertain the time required for the suspended matters to settle, a quantity of the water was placed in a glass cylinder. A 14-inch column required ten days in which to become clear.

Chemical Examination.—Ammonia, free, .025 parts per million; ammonia, albuminoid, .202 parts per million.

Sample No. 4.—December 24.

Appearance.—Clear and nearly colorless.

Chemical Examination.—Ammonia, free, trace; ammonia, albuminoid, .15 parts per million.

GREEN LAKE.

Sample No. 1.—Collected January 21, 1880.

Physical Characteristics.—Taste, some; odor, slight; appearance, nearly colorless, with numerous white flakes floating about which slowly settle. The white flakes are composed of algæ, to which some mineral matter, organic matter and diatoms adhere. One flake was composed entirely of wheat starch.

Chemical Examination.—Ammonia, free, .025 parts per million; ammonia, albuminoid, .344 parts per million.

Sample No. 2.—Collected February 3, 1880, at the outlet.

Physical Characteristics.—The appearance of the water was the same as that of January 21.

Chemical Examination. — Ammonia, free, .025 parts per million; ammonia, albuminoid, .345 parts per million.

Remarks.—After the specimens from Green Lake were examined, the jars containing them were kept closed until February 7, on which date a very disagreeable odor was perceptible, stronger than that from a sample of Grand River water kept at about 70 degrees F. since September 4, 1879, or that from a sample of Rouge River kept since December 24, 1879.

COMPARISON OF PHYSICAL CHARACTERISTICS.

COLOR.

GRAND RIVER.—Light yellow, slightly deepened as rains become more numerous and heavy.

INDIAN MILL CREEK.—During the dry weather preceding September 5 there was very little color, the heavy rains following deepening its color to a considerable extent more than they did that of hydrant water or the water of Grand River.

HYDRANT, COLDBROOK CREEK.—Slightly colored, changing but little during the season.

LAMBERTON LAKE AND CARRIER CREEK.—Colorless, or nearly so, and not affected appreciably by rain storms.

GREEN LAKE.—Colorless, or nearly so.

LAKE WABASIS AND ROUGE RIVER.—One sample only of each was examined, and found to be highly colored, and at a time when the waters of Lamberton Lake, Lamberton Creek, Carrier Creek, hydrant water and Green Lake were colorless.

ODOR AND TASTE.

CARRIER CREEK.—Odorless and tasteless.

INDIAN MILL CREEK, HYDRANT WATER AND COLDBROOK CREEK.—Nearly odorless and tasteless.

LAMBERTON LAKE, LAMBERTON CREEK, GRAND RIVER AND GREEN LAKE.—Some taste and odor—not pleasant.

REED'S LAKE.—Pond-like, and very marked.

NATURE OF SEDIMENT.

GRAND RIVER.—Composed in each sample of coarse brown flakes, with more or less of finely divided matter, the latter only partially separable by filtration through paper or sand, requiring from four to twelve days for complete subsidence. The greater portion of the sediment is iron, in the shape of ferric oxide. It also contains diatoms, numerous infusoria, and particles of vegetable matter and sand.

INDIAN MILL CREEK AND LAMBERTON CREEK, IN STORMY WEATHER.—Similar to that of Grand River, but containing less iron.

COLDBROOK CREEK AND HYDRANT WATER.—Similar to Indian Mill Creek, with the exception of the brownish flakes and the amount of iron, which is but a trace.

CARRIER CREEK, LAMBERTON LAKE AND GREEN LAKE. No appreciable sediment.

LAKE WABASIS AND REED'S LAKE.—Small quantity, with many animalculæ and considerable decomposing vegetable matter.

ROUGE RIVER.—Flocculent and of brownish color, containing infusoria, vegetable fiber and algæ.

SUMMARY OF CHEMICAL EXAMINATIONS.

Estimation of organic matter by ammonia process. Results expressed in milligrammes per litre (parts per million).

LOCALITY.	DATE.	AMMONIA.		REMARKS.
		FREE.	ALBUMINOID.	
Indian Mill Creek	Aug. 29, 1879	.025	.212	Dry weather.
" " "	Sept. 5, 1879	.025	.275	After first heavy rains.
" " "	Nov. 6, 1879	.012	.225	Cold; not much rain preceding.
" " "	Nov. 16, 1879	.020	.325	After several heavy rains.
" " "	Dec. 2, 1879	.050	.325	After continued heavy rains.
" " "	Dec. 24, 1879	.022	.180	Cold, and no rains.
Grand River	Aug. 29, 1879	.000	.425	Very dry; river very low.
" "	Nov. 7, 1879	.012	.178	
" "	Nov. 16, 1879	.015	.200	After heavy rains.
" "	Dec. 24, 1879	.020	.300	Cold; no rains.
Hydrant Water	Nov. 7, 1879	.025	.112	
" "	Nov. 13, 1879	.020	.225	Heavy rains Nov. 11 and 12.
" "	Nov. 16, 1879	.025	.200	Heavy rains.
" "	Dec. 24, 1879	trace	.150	Cold; no rains.
Coldbrook Creek	Sept. 6, 1879	.062	.220	After first rain following dr'ght.
" "	Dec. 24, 1879	.025	.220	Cold; no rains.

Carrier Creek	Dec. 2, 1879	.062	.115	After heavy rains.
" "	Dec. 24, 1879	trace	.150	Cold; no rains.
Reed's Lake	Dec. 2, 1879	.087	.375	Much rain recently.
Lamberton Lake	Dec. 2, 1879	.022	.287	Much rain recently.
" "	Dec. 24, 1879	.160	.275	Cold; no rains.
Lake Wabasis	Dec. 31, 1879	.060	.330	Cold; no rains.
Rouge River	Dec. 24, 1879	.037	.300	Cold; no rains.
Green Lake	Jan. 21, 1880	.025	.344	
" "	Feb. 3, 1880	.025	.345	
Lamberton Creek	Dec. 11, 1879	.175	.337	Recent heavy rains.
" "	Dec. 24, 1879	.020	.187	Cold; no rains.

NOTE.—In those instances where only one or two examinations were made, some knowledge will be gained by comparing with them other waters examined on the same date.

HARDNESS IN DEGREES PER CLARK'S SCALE.

GRAND RIVER.	INDIAN MILL CREEK.	COLDBROOK CREEK.	HYDRANT WATER.	REED'S LAKE.	LAMBERTON CREEK.
13	13.7	15	16.6	9	17
..	14.3	..	...	..	..

HUGO THUM, PH. C.

REPORT OF CHEMICAL EXAMINATION

OF INDIAN MILL CREEK WATER RELATIVE TO CONTAINED SULPHATE OF LIME, AND CLARK'S SOFTENING PROCESS.

GRAND RAPIDS, MICHIGAN, June 12, 1880.

A. C. SEKELL, *City Surveyor:*

SIR:—The sample of water from Indian Mill Creek sent me in June * contains .987 grains of sulphuric acid, expressed as $S.O.^4$, per United States gallon.

The sulphuric acid is united to the calcium and magnesium contained in the water, forming sulphate of calcium (sulphate of lime) and sulphate of magnesium.

To ascertain the amount of each of these salts requires considerable time, and is unnecessary for the object of this report, since, if all the sulphuric acid were calculated to sulphate of lime, we would obtain as a result but 1.4 grains of sulphate of lime per gallon, an amount not considered objectionable.

I have also made some applications of Dr. Clark's softening process to the water from Indian Mill Creek. In the few experiments made, the organic matter contained in the water was decreased one-half, the color was almost entirely destroyed, and its hardness reduced from 14.4 degrees to 4.4 degrees, Clark's scale.

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* At this time the flow of the creek was estimated to be about 11,000,000 gallons per day.

It is evident, therefore, that, by the application of Clark's process to Indian Mill Creek, the city will obtain a pure and soft water.

Yours Truly,

HUGO THUM, Ph. C.

ANALYSIS OF GRAND RIVER WATER.

June, 1879.

BY FERDINAND THUM, ANN ARBOR UNIVERSITY.

	Grains in U. S. gallon, 231 cubic inches.
Silica	.349,908
Sulphate of potassium	.353,698
" sodium	.396,779
" calcium	.401,577
Carbonate "	7.247,177
" magnesium	4.482,321
Ferric carbonate	1.490,024
Total	14.721,484

Table Showing Results of Analysis of Various Waters by Wanklyn & Chapman's Process.

RESULTS EXPRESSED IN MILLIGRAMMES PER LITRE (PARTS PER MILLION).

DATE.	LOCALITY.	AMMONIA.		
		Free.	Alb.	
	Glasgow, Loch Katrine	.00	.08	
1871	Chester (Dee)	.00	.07	
1871	Scarborough town water	.01	.06	
1873	Oxton town water	.00	.02	
1873	Chelmsford town water	.08	.02	
1873	Leek town water	.00	.02	
1872	Guilford, Surrey (new supply)	.00	.01	
1867	Caterham	.04	.00	Deep Spring Water.
	Frome, Somersetshire	.00	.02	
	Henley on Thames	.02	.02	
Dec. 1872	W. Middlesex Water Co.	.00	.01	
1867	Grand Junction Co.	.01	.07	
	Chelsea Co.	.01	.10	
July, 1867	Southwark and Vauxhall	.03	.16	
Feb. 1872	Southwark and Vauxhall	.01	.12	
July, 1867	Lambeth Water Co	.02	.14	
July, 1868	West Middlesex Water Co.	.01	.09	
June, 1874	River Nile	.01	.10	
July, 1874	River Nile	.04	.25	
Oct. 1876	Rhine at Berne	.10	.06	
	Sunderland in Durham	.03	.02	
May, 1876	Manchester	.03	.08	
	Near Yorkshire	.19	.11	
May, 1875	London, Aldgate pump	.50	.26	London Wells.*
Feb. 1875	" Bartholomew Lane	1.40	0.08	
March, 1876	" Queen Victoria St.	2.90	0.44	
	" Fell Street	52.82	0.52	
Jan. 1876	Well at Christ's Hospital	.10	.06	
June, 1876	Well at Blackfriars	.82	.04	
	London Water Supply Co. Thames	.01	.06	
	New River	.00	.06	
	Spring, Kent Co.	.01	.02	
	Thames at London Bridge	1.02	0.59	
	E. London Water Co. River Lea	.03	.09	
	" " " "	.01	.18	
Oct. 1867	Manchester town water	.01	.06	
	Edinburg	.00	.07	
	River Platte above Buenos Ayres	.07	.24	J. T. T. Kyle
	" Parana	.16	.24	
	" Uruguay	.07	.10	
1878	Niagara River	.14	.11	
1875	Ice, Rye Beach Hotel †	.205	.697	

* These wells have been closed by medical officer.

† This ice caused sickness among guests.

DATE.	LOCALITY.	AMMONIA.		
		Free.	Alb.	
Feb. 1880	Mystic water*	.34	.20	W.R. Nichols
Feb. 1880	Boston water	.04	.15	
March, 1880	Winchester water	.17	.09	
1873	Merrimac River above Lawrence	.044	.110	W.R. Nichols
	“ “ below “	.031	.127	
June, 1873	Charles River, at S. Natick	.043	.120	
June, 1873	“ “ at Dedham	.100	.189	
Sept. 1873	“ “ Newton Upper Falls	.057	.368	
Sept. 1872	Blackstone River, Uxbridge	.03	.109	
Nov. 1872	“ “ below Blackstone	.65	.350	
Jan. 1873	“ “ below Millbury	.19	.08	
Oct. 1873	Sudbury River above Ashland	.051	.184	
Sept. 1873	“ “ below Ashland	.06	.30	
Oct. 1873	“ “ at Framingham	.064	.247	
Sept. 1873	“ “ at Concord	.067	.247	
Sept. 1873	Concord River at “	.08	.271	
1873	Neponset River at Readville	.047	.270	
	“ “ at Hyde Park	.110	.300	
July, 1873	Cochituate Water, Boston	.033	.120	
June, 1873	Abajonna River†	.273	.241	W.R. Nichols
July, 1873	Lowell water, delivered	.02	.067	
Dec. 1873	Waltham Water, from house	.02	.013	
Sept. 1874	Shawshine River	.02	.12	
Sept. 1874	Sudbury river, below Ashland	.034	.36	
Sept. 1874	Mystic River, at lake	.084	.23	
Sept. 1874	Charles River	.026	.27	
Aug. 1879	Detroit River, at water works	.053	.129	A. B. Lynn.‡
Sept. 1879	“ “ at Belle Isle	.226	.121	
Sept. 1879	“ “ at water works	.065	.142	
Sept. 1879	“ “ below Detroit	.075	.175	
Jan. 1877	Ludlow Reservoir, Springfield, Mass.	.168	.368	W.R. Nichols
March, 1877	“ “ “ “	.024	.309	
May, 1877	“ “ “ “	.149	.189	
June, 1877	“ “ “ “	.075	.899	
Aug. 1877	“ “ “ “	.208	.331	
Sept. 1877	“ “ “ “	.058	.397	
1877	Average of 6 unfiltered samples	.094	.354	
	“ “ same filtered	.072	.294	
Dec. 1876	Rochester, N. Y., Hemlock Lake	.000	.010	S.A. Latimore
Dec. 1876	“ West Rush Reservoir	.000	.012	
	“ City Mains	.000	.012	
July, 1877	Boston, Hydrant Institute Technology	.048	.155	W.R. Nichols
Sept. 1877	“ “ “ “	.045	.155	
Oct. 1877	“ “ “ “	.048	.195	

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* Supplied to City of Boston.

† Main source, Mystic Lake, Charleston, water supply.

‡ Detroit Water Works Report, 1880.

REPORT

OF THE

BOARD OF PUBLIC WORKS

TO THE

COMMON COUNCIL OF THE CITY OF GRAND RAPIDS

TRANSMITTING THE REPORTS OF THE

SUPERINTENDENT, COLLECTOR & ENGINEER

OF THE WATER WORKS,

For the Year Ending April 30th, 1880.

ALSO THE

ANNUAL REPORT OF THE CITY SURVEYOR.

GRAND RAPIDS, MICH.
Stevens & Messmore, Printers, Court Block.
1880.

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1880.

BOARD OF PUBLIC WORKS

GEORGE W. THAYER, President.
(TERM EXPIRES MAY, 1882.)
LEWIS H. WITHEY.
(TERM EXPIRES MAY, 1880.)
THOMAS FARMER.
(TERM EXPIRES MAY, 1881.)
WM. P. INNES.
(TERM EXPIRES MAY, 1881)
WM. HOVEY.
(TERM EXPIRES MAY, 1882.)

OFFICERS.

A. C. SEKELL, City Surveyor.
THOMAS FARMER, Jr., Superintendent Water Works.
FRED. A. TWAMLEY, Clerk and Collector.
DEMETRIUS TURNER, 1st Engineer at Pumping Works,
GEORGE E. KIRK, 2d Engineer at Pumping Works.
S. M. BARROWS, TIMOTHY ROSE, Firemen
MICHAEL SCHMIDT, Watchman

REPORT OF THE BOARD.

BOARD OF PUBLIC WORKS,
GRAND RAPIDS, MICH , May 3, 1880.

To the Honorable the Mayor and Common Council of the City of Grand Rapids:

GENTLEMEN:—In accordance with established usage, the Board of Public Works respectfully makes to your honorable body its report for the year ending April 30th, 1880.

The report of Thomas Farmer, Jr., Superintendent of the Water Works, of Fred. A. Twamley, Collector of Water Rates, of Demetrius Turner, Engineer in charge of Pumping Works, and that of A. C. Sekell, City Surveyor, submitted herewith, furnish full information concerning all matters relating to that branch of the public service, by law committed to the supervision of the Board of Public Works. The gentlemen in charge of these departments have discharged the duties of their several positions in a manner most creditable to themselves and satisfactory to the Board.

On the 26th of May last the Board asked of your honorable body that they be authorized to make such surveys, examinations and investigations as would enable them to submit for your consideration, and that of the public, such recommendations looking to a more abundant and better source of water supply, as the facts developed by such surveys and examinations would warrant. Your prompt action in providing the necessary means, enabled the Board to issue to the City Surveyor the instructions required for his guidance in the work on the 7th of June, from which date.

to the present, he has given as much of his time to making the requisite surveys and investigations as his other more immediate pressing public duties have permitted. At this time, the field work is substantially completed, and it is expected that the Surveyor will soon be able to lay before the Board the result of his labors.

The compensation of the five members of the Board for the year ending May 1, 1880, aggregates $567.00, being somewhat in excess of the two previous years, in consequence of a large increase in the public improvements ordered by the Council to be carried on under the supervision of the Board, making more frequent meetings necessary.

Respectfully submitted,
GEO. W. THAYER.
THOMAS FARMER.
WILLIAM P. INNES.
WILLIAM HOVEY.
LEWIS H. WITHEY.

SUPERINTENDENT'S REPORT.

OFFICE OF THE BOARD OF PUBLIC WORKS,
May 1, 1880.

To the Honorable the Board of Public Works—GENTLEMEN:

I have the honor to submit the following report of the Grand Rapids Water Works for the year ending May 1, 1880, showing the general condition of the works, and particularly what has been done during the past year.

The works were commenced in October, 1873, at the close of which year about two miles of pipe had been laid In 1874 about ten and one-half miles of pipe were laid, the reservoir, pump house, pumping machinery and boiler were constructed. In 1875 six and one-half miles of pipe were laid and the settling basin built. In 1876 three and one-half miles of pipe were added, since which time no additions have been made to the main pipe system. In 1878 a duplicate pumping engine and boiler were set up at the pumping house.

RESERVOIR.

The pointing in the slope wall near the water line is partially washed out, and during the coming year it would be advisable to have such portions repointed. Aside from this there are no repairs necessary, which speaks well for the thoroughness of the original work, as this will be the only expense incurred by repairs since its completion, in 1874. The average depth of water maintained has been nineteen feet ten and one-half inches, and the least depth sixteen feet two inches, June 5th, owing to the fact of the shutting down of the pumping engine for sixty hours while cleaning the settling basin.

SETTLING BASIN AND SUPPLY CREEKS.

During the summer of 1878 numerous complaints were made at the Water Works office regarding the quality of the water furnished, more especially during the months of July and August. During these months the water had a very perceptible fishy odor and taste, the cause of which was attributed by the greater majority of complainants, to the presence of dead and decaying fish in the reservoir and main pipes. The reservoir was carefully examined and the mains thoroughly blown off, neither of which operations developed any signs of fish. The smell and taste continued at intervals for about two months. It was thought that by cleaning out the settling basin the difficulty might be overcome; accordingly, the water was drawn off during the night of the 3d of June, and work commenced the following morning. A large amount of vegetable growth was removed, aside from which nothing objectionable was found, and the trouble has never reappeared since that time; but judging from the experience of other cities whose water supply has been similarly affected, the remedy cannot, with certainty, be attributed to the removal of these weeds. The inside slopes of the basin were also cleaned, and all weeds, etc., removed from the banks. In January, owing to a sudden thaw and violent rains, Coldbrook Creek overflowed its banks and washed out the dam built to divert the creek into the settling basin, also the dam near the gate house built to protect the supply pipe where it goes under the creek. The latter dam was repaired first, as the supply pipe was in imminent danger of being washed out, and had this occurred, it would have entailed a large expense for repairs, beside shutting off the supply of water for the city.

The past two years the Board have employed a watchman on Coldbrook and Carrier Creeks to devote his whole time during the summer, and one or two days in the winter months. He has been the means of keeping the creeks, in a great measure, free from pollution, but few offenses having been committed, and all such have been promptly reported to the proper authorities.

MAINS.

The six inch iron pipe in Lyon Street, at Nelson & Matter's shop, broke off about half-past seven o'clock A. M., October 14th, owing to the caving in of the tail race. The pipe was plugged, and on the completion of the new tail race in December the plug was removed and the connection again made with the safety valve at the river. One joint in the wrought iron pipe under the river was found leaking and repaired, and with these two exceptions, the iron pipes called for no repairs. "The Wyckoff Patent Wood Pipe" is in good condition. As in former years, the trouble has been with the joints, they seemingly being the only weak point in the pipe; the tar coating still remains firm, and the iron, with which they are banded, bright. The expense for maintaining this pipe has heretofore been borne by the contractors, Messrs. Farrington & Branch, but their five year guarantee having expired December 1, 1879, the expense is now borne by the city. A section of pipe which was laid in 1874, was taken up the past year, and was apparently as sound as when laid. The pump logs on the hill are doing good service. Three have burst during the year, owing, in each instance, to the too sudden closing of hydrants. There have been four other leaks in the logs, three caused by the blowing out of loose knots, and one at a joint. Of the supply pipe, nothing need be said, as you are well acquainted with its condition, a report within a year having covered all that now might be said. The annexed table shows the total number of leaks in the different kinds of pipe:

Kind.	Joints.	Knots.	Checked.	Bands burst.	Total.
Wyckoff..	28	2	1		31
Pump logs.	1	3	3		7
Cast iron.	One Pipe	broken off.			1
Wrou't ir'n	1				1
Stave.....			7	17	24
Total......	30	5	11	17	64

HYDRANTS.

All the hydrants have been examined and have all been opened once, and the greater majority twice during the year, by the water department, and have been used by the Fire Department 74 times; the greatest number of streams at any fire, 9. They have all been painted, and the boxes enclosing them cleaned out. Three have been raised to conform to street grades, and one new one set at the Chair Factory on Canal Street. A number of new valves have been put in to replace those injured by stones. They have not, in any instance, failed to answer all demands of the Fire Department.

VALVES.

The valves have given but little trouble. A number of stuffing boxes were repacked, and the glands set up on some others which were leaking. They have been painted with asphaltum and coal tar and are in good order. The boxes enclosing the hydrants and valves are made of two inch pine plank, and have, in a number of instances, rotted nearly out, making them a source of danger to passing teams. I would recommend that they be replaced, where necessary, with iron boxes, or bricked up and cemented on the inside. Either of these plans would be more expensive than the wooden box system, but their greater security to public travel, aside from the fact that the cost of maintenance would be slight in future years, would amply repay their increased cost.

SERVICE CONNECTIONS.

Eighty-nine services were laid the past year, including one two and one-half inch for a water elevator, making the total number now laid to May 1, 898. The wisdom of laying lead pipe for services is now made apparent from the fact that a number of the wrought iron pipes which were used at the commencement of the works for service pipe have given out, and have been replaced with lead pipes. Considerable trouble and inconvenience has been caused in the past by the removal of the service box covers and the filling of the boxes with sand or stones. The action of the Board in adopting the Bingham & Morgan shut-off boxes has entirely obviated this difficulty.

METERS.

The number of meters now in operation is 90, of the following kinds:

Ball & Fitt's Rotary, 7.
" " Piston, 76.
Worthington, 7.

There are also eight meters in the shop, four of which are worn out and unfit for use. The rotaries have been in use for two and one-half years, and have given entire satisfaction, and in consideration of the fact that the water contains an amount of sediment which is very destructive to the piston meters, I would recommend the adoption of the rotary meter.

The past year the receipts from metered water were one-third of the total revenue, while the number of consumers taking water through the meters was but one-tenth of the total number assessed. This, added to the fact of their being the means, in a number of instances, of detecting leaks which would otherwise have not been suspected, makes them doubly valuable to the works. Little, if any, of the water passed through meters is willfully wasted, and the increased waste of water is in a measure accounted for by the fact that when there were but 500 services we had the same number of meters as at present. Now we have over 800 services open, and to meter the same proportion of services as we then did, would require the use of 160 meters, or the purchase of 63 additional ones. Last summer the water supply for a period of ten days, was insufficient to meet the demand, and but for the intervention of Providence, in the shape of a two days rain, a water famine would have been imminent. The purchase of a number of meters would, for the above reasons, materially assist in bridging over the anticipated short supply the coming season.

DRINKING FOUNTAINS.

The five public drinking fountains put in operation two years ago are a failure. The waste pipes are too small, and are, as a general thing, completely filled up with gravel, sticks, etc., and, as a consequence, there is a mud hole in the street, and the sidewalks are more or less sloppy in their vicinity. They should be taken up and replaced with a well-constructed fountain arranged in such a manner as to furnish water, not only to the thirsty citizens, but also to horses and dogs. Fountains of this description are extensively used in other cities, and are highly appreciated both by man and beast. The expense of erecting them would not be large, as the present service pipes could be used to supply them. If the old fountains remain in they could be greatly improved by arranging the waste pipe in a way that it could not be stopped up, and by making them self-closing.

PUMPING HOUSE.

The pumping house has been thoroughly repaired, the walls plastered and the machinery handsomely painted.

The total length of main pipe now laid is 22.28 miles; number of hydrants, 235, and number of valves, 132.

Respectfully submitted,

THOMAS FARMER, Jr.,
Supt. W. W.

COLLECTOR'S REPORT.

OFFICE OF THE BOARD OF PUBLIC WORKS,
May 1, 1880.

To the Honorable Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—I respectfully present the following report for the year ending April 30, 1880:

The number of services on the 1st of May, 1879, for which permits were issued, were	773
Taps granted without permits	20
Private mains connected with works	16
Total	809
Number of services put in the past year for which permits were issued	89
Total number of connections on May 1, 1880	898
Number of services now cut off	79
Number of services now open	819

The receipts at this office for the year have been as follows:

From water rates	$ 15,157 48
" " permits	599 25
" Farrington & Branch, for repairs	416 82
Total income from Water Works	$ 16,173 55

There has also been received from sewer permits	51	00
Total receipts for the year	16,224	55
Cash on hand May 1, 1879	205	37
	$ 16,429	92

Deposits have been made with the City Treasurer during the year, as follows:

To the credit of Water Works income fund	$ 15,940	67
“ “ “ 1st District sewer fund	40	50
“ “ “ 2d “ “ “	10	50
Total deposits during the year	$ 15,991	67
Cash on hand to balance	438	25
	$ 16,429	92

Receipts previous to May 1, 1879:

From water rates	$ 44,447	23
“ “ permits	4,006	98
“ sewer “	282	00
“ Farrington & Branch, for repairs	304	00
“ various sources (as per last report)	222	59
Total	$ 49,262	80
Receipts for the past year	16,224	55
Total receipts to date	$ 65,487	35

Deposits made previous to May 1, 1879:

To the credit of Water Works income fund	$ 48,699	53
“ “ “ “ “ fund	264	90
“ “ “ 1st District sewer fund	81	00
“ “ “ 2d “ “ “	12	00
Total	$ 49,057	43
Deposits made the past year	15,991	67
Cash on hand to balance	438	25
Total	$ 65,487	35

STATEMENT OF EXPENDITURES.

May 1, 1879, to May 1, 1880.

CONSTRUCTION OF WATER WORKS.

1. Pipe System.

Special casting	$ 6 75	
1 new hydrant	46 75	$ 53 50

2. Pumping House and Grounds.

Completing pump house		$ 497 44

3. Duplicate Pumping Machinery.

Construction (balance)	$1,020 79	
Lubricators, connections and gauge case	65 66	$ 1,086 45

4. Meters.

3 new meters		$ 123 33

5. Additional Supply.

Surveys, plans, etc		$ 945 70
Total paid on construction		$ 2,706 42
Paid previous to May 1, 1879		401,589 59
Total paid for construction to date		$404,296 01

MAINTENANCE AND OPERATION OF WATER WORKS.

1. Pumping.

Salary, Engineer	$ 987 50
" Assistant Engineer	810 00
" 2 firemen	1,035 00
Fuel	2,669 57
Repairs to pumping machinery	375 58
" " boiler arches	68 82
" " Engine House	103 58
Supplies (oil, packing, etc.)	359 68
	$ 6,409 73

2. OFFICE AND COLLECTING.

Salary, Collector	$ 540 00
Printing and advertising	32 35
Stamps and stationery	59 10
Freight, fuel, etc	37 94
	$ 669 39

3. SUPERINTENDENCE AND REPAIRS.

Salary, Superintendent	$ 1,000 00

REPAIRS.

1. IRON PIPE.

Labor	$ 12 05	
Material	9 00	$ 21 05

2. WYCKOFF PIPE.

Labor	$ 198 85	
Material	59 82	$ 258 67

3. PUMP LOGS.

Labor	$ 10 00

4. SUPPLY PIPE.

Labor	$ 149 70	
Material	54 42	$ 204 12

5. HYDRANTS.

Labor	$ 85 88	
Material	56 44	$ 142 32

6. METERS.

Labor	$ 29 25	
Material	16 14	$ 45 39

7. SETTLING BASIN.

Labor		$ 70 50

8. SUPPLY CREEKS.

Salary, Watchman	$ 86 00	
Labor	62 70	$ 148 70

9. SERVICE CONNECTIONS.

Labor	$ 18 06	
Material	375 94	$ 394 00

10. MISCELLANEOUS.

Tools	$ 25 24	
Blowing off	18 00	$ 43 24
		$ 2,337 99

RECAPITULATION.

Pumping	$ 6,409 73
Office and collecting	669 39
Superintendence and repairs	2,337 99
Total paid for maintenance and operation	$ 9,417 11
Paid previous to May 1, 1879	40,024 35
Total paid to date	$ 49,441 46
Income for the year	$ 16,173 55
Cost of maintenance and operation	9,417 11
Excess of receipts over expenditures	$ 6,756 44
Income for the past year	16,173 55
Income for the year ending May 1, 1879	13,734 58
Increase in receipts	$ 2,438 97

Respectfully submitted,

FRED A. TWAMLEY,

Collector.

ENGINEER'S REPORT.

GRAND RAPIDS, MICH., May 1, 1880.

To the Honorable, the Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—I have the honor to submit herewith my annual report of the work done by the pumping engines for the year ending April 30, 1880.

The engines have been running on 361 days, making a total of time run 3,213 hours and 15 minutes, against 342 days, or 2,779 hours and 50 minutes run the previous year.

The total number of revolutions made was 4,042,099 against 3,347,105 the year previous.

The new duplicate pumping engine which was completed early in the year, commenced running May 25th, and has been in operation a large portion of the time since.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, and amount of wood burned. The estimated quantity of water pumped per revolution is 100 gallons:

MONTH.	Days Pum'd	Time run. H. M.	Number of Revolutions.	Gallons water pumped.	Cords of wood used	Cost of wood used.
May	29	259:05	326,132	32,613,200	110¾	$ 111 65
June	27	295:25	360,089	36,008,900	151	211 40
July	31	304:00	384,634	38,463,400	174	243 60
August	31	315:30	401,121	40,112,100	190	262 00
September	30	262:25	330,200	33,020,000	175	245 00
October	31	271:30	328,014	32,801,400	163	228 20
November	30	234:20	298,826	29,882,600	152	212 80
December	31	251:35	322,031	32,203,100	173	242 20
January	31	254:05	328,017	32,801,700	149	208 60
February	29	241:35	311,505	31,150,500	153	214 20
March	31	266:15	329,804	32,980,400	149½	231 72
April	30	257:30	321,726	32,172,600	136¾	211 96
Total	361	3213:15	4,042,099	404,209,900	1,877	$2,623 33

Average daily consumption, 1,107,427 gallons, against a daily average the year previous of 897,024 gallons, or an increase of over 23 per cent.

Approximate daily consumption for each service 1,401 gallons, against 1,281 gallons the previous year.

The running expenses for the year have been :

For salaries	$2,832 50
" fuel	2,623 33
" repairs	444 40
" oil, packing, etc	353 53
Total	$6,253 76

Average lift of water not including friction in pump and force main, 150 feet.

Total cost of raising one million gallons into reservoir	$15 47
Total cost of raising one million gallons one foot	0 10 31-100
Total cost of fuel for raising one million gallons into reservoir	6 49
Total cost of fuel for raising one million gallons one foot	0 04 32-100

Respectfully submitted,
DEMETRIUS TURNER,
Engineer of Pumping Machinery.

REPORT OF CITY SURVEYOR.

CITY SURVEYOR'S OFFICE,
GRAND RAPIDS, MICHIGAN, May 1, 1880.

To the Honorable Mayor and Common Council of the City of Grand Rapids:

GENTLEMEN:—I have the honor to submit the following annual report concerning the improvements conducted by the Board of Public Works during the past year.

STREETS.

The street improvements which have been completed during the year are shown by the following table, which exhibits the character and cost of each, and also the street improvements now under contract and not completed:

Street Improvements Completed During Year Ending April 30, 1880.

Name of Street.	From.	To.	Kind of Improvement.	Length.	Cost.				Contractors.
					Construction.	Assm't etc.	Total.	Per foot.	
Plainfield Ave......	Taylor............	Coldbrook......	Graded, graveled and gutters paved..........	647 ft.	$ 672 30	$136 99	$1109 29	$1 71	L. D. Leonard......
Taylor	Coldbrook	N. W. line Plainfi'd ave	" " "	237 "	505 20	127 32	632 52	2 67	L. D. Leonard......
St. at Settl'g B'n.	Clancy	Coldbrook	Graded and graveled..	600 "	404 40	....	404 40	0 67	L. D. Leonard......
Third Ave............	S. Division......	S. Ionia..........	Graded, graveled and gutters paved..........	594 "	899 75	68 85	968 60	1 63	Utes & Livingston
Packard...............	Cherry	Lake Ave........	" " "	729 "	1011 84	70 55	1082 39	1 48	Leonard & Waters
Jefferson Ave.......	Cherry	E. Fulton........	Cobble stone & cedar blk pavement..........	1254 "	4264 27	228 35	4492 62	3 58	C. Prango.............
First Ave............	Buchanan......	Hilton	Graded, graveled and gutters paved..	163 "	383 00	Not comp'd 5 50	388 50	2 38	C. Prango............

Street Improvements Commenced During the Year and Not Completed.

Name of St.	From.	To.	Kind of Improvement.	Length.	Estimated Cost.				Contractors.
					Con-struc'n	Assm't &c.	Total.		
Watson	S. Front.....	Shepard...........	Graded and graveled.........................	3311 ft.	$2100 00	$200 00	$ 2300 00	....	Farr & White..........
W. Fulton	S. Front.....	Shepard...........	" " "	3767 "	3800 00	200 00	4000 00	....	Farr & White...........
Canal..	E. Bridge..	N. City Limits	Cedar block re-paving.....................	7959 "	10450 00	1100 00	11550 00	....	Utes & Livingston..
Cypress	Fifth	North...	Graded and graveled..	5878 "	5550 00	350 00	5900 00	....	Utes & Livingston..
Bronson-st, & Cresent ave..	Kent	N. Prospect.....	Graded, graveled, & gutters paved	3770 "	14500 00	450 00	14950 00	....	McBrian & Farr......
S. Front...........	Allen.........	W. Bridge.......	" " " " "	1204 "	2220 00	130 00	2350 00	....	A. Wiseman............
S. Front...........	Allen.........	Butterworth-a	{ Graded, graveled & gutters pav'd { Graded and graveled	900 " 1993 " }	8097 00	228 00	8325 00	....	C. Prango..................
Prescott...........	S. Division	Grandville av	Graded, graveled, & gutters paved	2072 "	4945 00	175 00	5120 00	....	C. Prango..................

The total estimated length of the streets now opened in the city is 132.57 miles, of which there are:

Graded and paved with wood	0.07	miles
Graded and paved with wood and stone	3.96	"
Graded and paved with stone	1.55	"
Graded, graveled and gutters paved	23.28	"
Graded and graveled	28.95	"
Graded	7.48	"
Unimproved	67.28	"
Total	132.57	miles

SEWERS.

The total estimated length of the sewerage system is 17.99 miles, of which there are of

Brick sewers	8.02	miles
Glazed pipe sewers	7.90	"
Cement pipe sewers	0.48	"
Wood Sewers	1.59	"
Total	17.99	"

The following tables show the sewers completed during the year, with their location and cost, and also the sewers now under contract and uncompleted:

Sewers Completed During Year Ending April 30, 1880.

Name of Street.	Location.	Size and Kind.	Man Holes.	Catch Basins	Length in feet.	Cost.			Contractors.
						Construction.	Assm't &c	Total.	
Prescott, &c.	From 20 feet E. of S. Ionia St., E. in Prescott St. to S. Division St., S. to Blakeley Ave., E. in Blakeley Ave. to Center St., S. to alley, E. in alley to alley running N. and S., S. to Pleasant St., thence E. to S. Lafayette St.	16x24 in. brick 18x27 " " 20x30 " " 22x33 " " 36x54 " "	8	8	307 300 827 964 558	$4081 28	$1209 38	$5290 66	Utes & Livingston.
Cass	Pleasant St. to 50 ft. N. of Fifth-a.	12 in. glazed pipe	2		984	935 91	112 00	1047 91	Prange & Weirich.
Cass	Wenham-ave. to 50 ft. N. of Pleasant St.	12 " " "	2		935	894 16	94 60	988 76	Utes & Livingston.
W. Fulton	Winter St. to W. Broadway	18x27 in. brick 15 in. glazed pipe 12 " " "	4	10	533 889 328	1665 80	232 75	1898 55	A. Wiseman
N. Ionia	Lyon St. to 75 ft. S. of Bronson St.	12 " " "	2		463	398 10	76 55	474 65	J. Collins
N. Ionia	Bronson St. to 100 ft. S. of E. Bridge St.	12 " " "	2		476	480 90	71 75	552 65	J. Collins
Alley bet N Prospect & N. Lafayette	Fountain St. to 97 ft. S. of Lyon St	12 " " "	2		640	550 00	78 75	628 75	Utes & Livingston.
Washington	Madison Ave. to College Ave	12 " " "	3		660	592 00	92 05	684 05	J. Collins

Sewers Commenced During the Year and Not Completed.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man Holes.	Catch Basins	Length in feet.	ESTIMATED COST.			CONTRACTORS.
						Construction.	Assm't &c	Total.	
Winter St Sewer extension in Broadway St.	In W. Bridge from Winter St. sewer to Broadway St., N. in Broadway St. to North St.	12 in. glazed pipe..... 20x33 in, brick......... 35x45 " " .... 41x53 " " .... 56x72 " "	18	40	1410 1222 1311 1303 2804	$25547 00	$1203 00	$26750 00	McBrian & Farr...
Lagrave..................	Wenham Ave. to Wealthy Ave......	12 in. glazed pipe.....	1	1	561	572 00	58 00	630 00	Joel Collins...........
Bank.....................	S. line lot 8, Kent plat, to 40 ft. S. of E. Bridge............................	9 " " "	2		200	210 00	40 00	250 00	Joel Collins...........

LEONARD STREET BRIDGE.

A new bridge has been built across Grand River at Leonard Street.

The bridge is of wood of the pattern known as the Town Lattice, with the addition of Howe Truss lateral bracing. The roof is shingled, the sides left open. In addition to the lateral bracing each span is provided with six knee braces engaging overhead tie beams, which are bolted to the top chords. The portals are ornamented with bracket and scroll work, which, together with the hand rail, are well painted.

The principal dimensions are as follows:

Number of spans	8
Length of span	104 feet
Extreme width	32 "
Roadway	18 "
Sidwalks each	5 "
Height, out to out of chords	17 "
Lattice plank	3 by 10 inch
Chord "	3 by 12 inch

The timber used was white pine, of excellent quality. The pins are of seasoned oak and were coated with linseed oil before driving.

The contract was awarded October 8, 1879, to L. B. Boomer & Co., of Chicago, Ill., and the final account for construction was allowed by the Board, March 27, 1880.

The total cost, including stone coping on the old piers, new buttresses and wing walls and filling at approaches, was $10,561.70.

ENGINE HOUSES NOS. 2 AND 5.

Two engine houses have been commenced during the year, which are now substantially completed and ready for use.

Engine House No. 2 is located on Barclay Street near East Bridge Street.

Engine House No. 5 is located on the southwest corner of Canal and East Leonard Streets.

These houses have been constructed from designs prepared for the City Surveyor by Robinson & Barnaby, architects, of this city. For excellence of design, substantial construction, and completeness in detail, it is believed they will compare favorably with any buildings of the kind in this country.

Engine House No. 2 has a frontage on Barclay Street, of forty-four feet, and a depth from front to rear of seventy-six feet.

A basement in the rear contains storage room for coal and the furnace and steam boiler for heating the building.

The foundation walls are of rubble masonry, the main walls of brick. The front is faced with white tile brick, relieved by red brick ornamentation and cut stone. Water tables, sills, etc., are of cut stone; copings, gables, etc., are finished with galvanized iron.

The roof is covered with "Warren's Patent Natural Asphalt Roofing," and is warranted by the manufacturers for fifteen years.

The first story, fifteen feet high, contains the office, in which will be found the necessary telegraphic apparatus, and the Engine Room.

The Engine Room floor is paved with cedar block pavement, and is intended to accommodate a steamer and hose carriage, immediately in the rear of which are stalls for four horses.

In the rear of the stalls a partition separates the Engine Room from the rear, where are rooms for harness, bedding and other conveniences, including stairs to basement, and hayloft above. There is also in this part of the building a sink with city water, and also outside a soft water cistern and pump, to force soft water to tank in second story, which supplies the bath tub and wash basins. Another tank furnishes soft water to the boilers.

On the first story is located under the staircase a water-closet room, with Jenning's patent closet, wash-stand with marble slab and basin, furnished with plated furniture.

Two staircases lead from Engine Room to second story. These are built with oak, and have landings provided with swinging doors.

The second story is twelve feet high, and is to be used as a dormitory. It is well lighted and ventilated by handsome windows on every side of the room.

Adjoining the dormitory is a large bath room with bath tub, lined with tinned planished copper. Immediately over the office is a room on second floor, whence access is had to the tower.

The tower is on northwest corner of the building, contains office on first floor and hose well fifty feet high, for drying hose. The tower roof is slated with black slate.

Surmounting the tower a campanile with lofty flag-staff rsies to a height of 105 feet from the street below.

The enclosed bell-deck affords a magnificent view of the entire city.

Two large entrance doors in the front afford ample means of exit, while a door in the tower and two in the rear of the building are provided.

The building was built by Dannals & Carroll, of this city. The contract price was $5,078.

Engine House No. 5, on Canal Street, has a frontage of fifty-five feet, and a depth of seventy-six feet. This building is somewhat wider than No. 2, but has been built after the same general design and arrangement.

It has a large ornamental hose and bell tower, reaching to a total height of one hundred and ten feet above Canal

Street, to the top of the flag staff. The building presents a fine architectural appearance.

The building is heated throughout by steam supplied to radiators through the building from a boiler in the basement. Bathrooms, water and gas is provided as in No. 2.

The building has been built by J. H. Courtney, of this city. The contract price was $6,688.

The steam heating apparatus in both buildings has been put up by Sproul & McGurrin, of this city. The contract price for this work was $1,125.

The following is the cost of the several improvements which have been completed during the year, including incidental expenses, but not including the cost of superintendence on bridge and engine houses:

Street improvements	$ 9,078 32
Sewerage	11,565 98
Leonard Street Bridge	10,561 70
Duplicate Pumping machinery	11,520 79
Total cost of completed work	$42,726 79
Paid by Board on incomplete work	15,166 04
Total	$57,892 83
Paid on above prior to May 1, 1879	14,713 98
Leaves amount paid during year	$43,178 85

Respectfully submitted,

A. C. SEKELL,

City Surveyor.

ANNUAL REPORT

—OF THE—

Board of Public Works

—AND—

CITY SURVEYOR,

—OF THE—

CITY OF GRAND RAPIDS,

For the Year ending April 30, 1881.

GRAND RAPIDS, MICH.
EAGLE PRINTING HOUSE.
1881.

REPORT

—OF THE—

Board of Public Works

—TO THE—

Common Council of the City of Grand Rapids,

Transmitting the Reports of the

SUPERINTENDENT, COLLECTOR AND ENGINEER

OF THE WATER WORKS

For the Fiscal Year ending April 30, 1881.

—ALSO THE—

ANNUAL REPORT OF THE CITY SURVEYOR.

GRAND RAPIDS, MICH.
EAGLE PRINTING HOUSE.
1881.

BOARD OF PUBLIC WORKS

GEORGE W. THAYER, President.
(TERM EXPIRES MAY, 1882.)

THOMAS FARMER.
(TERM EXPIRES MAY, 1881.)

WM. P. INNES.
(TERM EXPIRES MAY 1881.)

WM. HOVEY.
(TERM EXPIRES MAY, 1882.)

CHARLES C. COMSTOCK,
(TERM EXPIRES MAY, 1883.)

OFFICERS:

A. C. SEKELL, City Surveyor and Sup't Water Works.
FRED A. TWAMLEY, Clerk and Collector.
DEMETRIUS TURNER, 1st Engineer at Pumping Works.
GEORGE E. KIRK, 2d Engineer at Pumping Works.
S. M. BARROWS, TIMOTHY ROSE, and GEO. H. BARROWS, Firemen.
JOHN J. HOEY, Foreman of Repairs.
MICHAEL SCHMIDT, Watchman.

Report of the Board.

BOARD OF PUBLIC WORKS,
Grand Rapids, Mich., May 1, 1881.

To the Honorable, the Mayor and Common Council of the City of Grand Rapids:—GENTLEMEN:

The Board of Public works respectfully submit to your Honorable body, its report for the year ending April 30, 1881.

The report of the Superintendent of the Water Works, Collector of water rates, Engineer of the Pumping Works, and the City Surveyor, are herewith laid before you.

The report of the Superintendent gives very full information in relation to all matters under his charge. That portion of it referring to the farther introduction and use of Water Meters, will be found to be of particular interest, fully sustaining the reasons presented by the Board to the Council when asking for an appropriation of money, that meters might be purchased and brought into more general use.

The receipts from water rates, and from other sources connected with the Water Department, together with the detailed statement of expenses, and of expenditures for construction during the last year, and for previous years since the commencement of the Works, will be found in the report of the Collector.

The report of the Engineer at the Pumping Works, shows the amount of water supplied and the cost of that branch of the service.

Full and complete inventories of all personal property belonging to the city, in charge of the Board, form part of these reports.

For a detailed statement of streets improved, sewers constructed, and other public work under the supervision of the Board, you are invited to examine the report of the City Surveyor.

It gives the Board pleasure to commend Mr. A. C. Sekell, Superintendent of the Water Works and City Surveyor, Mr. Turner, Engineer in charge of the Pumping Works, his efficient assistant, Mr. Geo. E. Kirk, and Mr. Fred A. Twamley, Collector of water rates and Clerk of the Board, for the faithful and efficient manner in which they have discharged the duties of their several positions.

Respectfully submitted,

GEO. W. THAYER,
THOMAS FARMER,
WILLIAM P. INNES,
WILLIAM HOVEY,
CHARLES C. COMSTOCK,
Board of Public Works.

Superintendent's Report.

Office of Superintendent of Water Works,
Grand Rapids, May 1, 1881.

To the Honorable Board of Public Works:

Gentlemen:—I have the honor to submit herewith the annual report for the year ending April 30, 1881.

RESERVOIR.

The Reservoir is in good condition, and no expenditure for repairs or improvements has been found necessary during the year. The pointing in the slope wall at the water line has been nearly destroyed by the continued action of the water since the reservoir was built, and during the coming season it will be advisable to have the same renewed.

Numbers of noxious weeds and shrubs have obtained a foothold on the outer slopes, which it will be well to remove.

The roof and cornice of the gate-house should be repainted, and I would also recommend the construction of another gate-house on the west side of the reservoir, to protect the valve at that point, which is now in a somewhat exposed condition.

I would also suggest that the grounds surrounding the reservoir belonging to the city, be enclosed with a suitable fence, and improved by grading so far as can be done without undue expense that the portion set off for a highway on the northwest part of the grounds be graded and graveled, and that a small sum be invested in the planting of trees.

These improvements would not only be for the public convenience, but they would tend to render attractive what is now somewhat desolate and forbidding in appearance.

SUPPLY PIPE.

At a session of the Common Council, held October 25, 1880, the City Clerk was instructed to notify the Board, that the Common Council had in the annual estimate for the year provided for the expenditure of the sum of $8,000, for the purpose of replacing the supply pipe connecting the settling basin and the pumping works, with one of iron, as recommended by the Board.

On November 8, the Board ordered the purchase of the pipe, and on November 27, a contract for the laying was awarded to C. Prange and George Kelly.

The work is now completed with the exception of making the connections at the ends which has been delayed on account of the continued high water.

SETTLING BASIN AND SUPPLY.

The completion of the new supply pipe will enable a somewhat greater quantity of water to be carried in the settling basin than has hitherto been found advisable, and it is hoped that the quality of the water will be thereby improved.

The dams which were built to control the height of water in the supply creeks, are in a very bad condition, and should be rebuilt at once, and with a material more durable than pine plank.

The outlet drain from the settling basin is a combination of sewer tile and plank box, and is in a decidedly bad condition. It should be relaid at once with iron.

The inlets to the basin are also in bad shape. They should be entirely rebuilt in a durable manner, and provided with suitable screens.

It may also be necessary to introduce a puddle wall into the slope on the southwest corner of the basin, before it can be safely filled to the desired depth.

The question of additional supply has yet to be decided.

It cannot be questioned that a supply, the gathering ground for which is largely within the limits of the city, and liable soon to be crossed by graded streets, and occupied by increased population, cannot much longer retain its original purity. The necessity for a larger quantity of water than is now available during the summer months, is a pressing one. During July and August of the past years there have been pumped as follows:

In	1876,	41,129,200	gallons.
"	1877,	46,358,084	"
"	1878,	63,122,169	"
"	1879,	78,575,500	"
"	1880,	82,361,700	"

The water flowing in the supply creeks in July and August of 1879 was barely sufficient to meet the demand, but during last year no trouble was experienced, the season being a wet one. Should the coming season be marked by long periods of dry weather serious danger from a short supply may be expected.

SERVICE CONNECTIONS.

Fifty permits were issued during the year for service connections, which is the smallest number ever issued.

One four inch service was put in for a stand pipe for fire protection.

The total number of services is 949, of which 100 are shut off.

Experience shows, that the use of iron pipe for services, especially under business blocks, is unwise, and often results in great waste of water, and liability to damage from leaks. A very few years suffices for the rust to weaken the pipe, so that it may burst at any time.

A number of services, amounting to about 100 were laid soon after the building of the works, without shut-off cocks, so that now, whenever it is necessary to shut off the water, the street must be dug up and the corporation cock used. Some steps should be taken to remedy this matter, or much expense and annoyance will continue to result.

The old wooden shut-off boxes used prior to the adoption of iron boxes in 1878, give continued and increasing trouble. There are about 400 which are fast rotting out, and becoming filled with earth or stone, so that in nearly every case, when opened for use, they are found choked up or entirely destroyed. Iron boxes should be substituted for these as fast as possible, not only for the interest of the city, but for the interest of the water consumer as well.

HYDRANTS AND VALVES.

The hydrants and valves are generally in good condition.

Five hydrant extensions were put on during the year, to conform to new street grades.

Hydrants have in one or two cases given trouble, by the breaking of the holding down bolts, and by the failure of the waste valves to work properly. Some trouble with hydrants has also been occasioned by the breaking of the brass stems. During the severe cold weather, several of the hydrants were found frozen; these were immediately thawed out.

Two of the post hydrants, standing near area walls, gave trouble when opened, by the formation of ice in the hydrant base, closing the waste hole.

The valve boxes and the Lowry hydrant boxes were built originally of pine plank, and are now generally in an unsafe and dangerous condition. I would recommend that they be replaced as rapidly as possible, either with brick or iron.

METERS.

The total number of meters now set and in operation is 188, of the following kinds:

Ball & Fitts, Rotary, Rubber floats,	45
" " " Bronze "	55
Worthington,	7
Crown,	6
Ball & Fitts, Piston	70

There are in the shop, old meters, as follows:

Worthington	1
Ball & Fitts, Piston	9
" " Rotary, bronze,	1
" " " Rubber	1

There are in stock, new meters, as follows:

Ball & Fitts, Rotary, Rubber floats,	41
" " " Bronze,	40
Crown,	5
Total number meters owned by city	281

The Common Council on December 20, 1880, ordered the transfer of $5,000 to the water works fund, to be used in the purchase of additional water meters, as recommended by the board. At that time there were in use 91 meters the experience with which had satisfied the Board of the advisability if not the imperative necessity of setting meters on all large users, business blocks and manufactories.

Soon after the notice of the appropriation, the additional meters were purchased and the setting commenced and carried on as fast as possible.

It could not be expected that the general introduction of meters could be accomplished without much opposition from the believers in the use as you please system; but the experience with the new meters serve to establish the former opinions as to the necessity for their use.

The objects sought by the meter are: First, to prevent waste, either willful or from the employment of leaking fixtures; second, to secure to the consumer who exercises due care in the use of water the consideration to which he is entitled, and third, to afford the means of applying a penalty for waste and neglect, which imposes a burden otherwise borne by the community at large; that is, to secure justice to all who are taxed to maintain the water works system.

Very prominent is the desire to prevent waste, which is the curse of all water works, involving as it does, the most lavish expenditures for additional supplies.

A few examples from our experience with the meters recently set, will show conclusively what can be accomplished in this direction,

On February 14, 1881 Meter No. 13893, was set on a service supplying a business block of three stores, with boarding house above. After running 45 days, the meter was read and found to have registered a daily average of 13,008 gallons or at the rate of 4,747,920 gallons per year, which is nearly one per cent of the total annual pumpage, amounting in value at the rate of 15 cents per 1,000 gallons, to $712.05.

The annual water rent charged was $85.56.

The proprietor was notified, and after a persistent search of several days a hole was found in the iron service under the basement floor, the water from which passed directly into the sewer. This leak was immediately repaired, since which time the meter has registered a daily average of 881 gallons, or an annual reduction of 4,426,355 gallons of water.

Meter No. 13887 was set February 24, 1881, on a four story building, containing one store. This meter registered up to April 1 a daily average of 2,752 gallons per day. When examined by the proprietor, a connection with the old Hydraulic Co's pipes was found, which was not wholly closed as it should have been. This was remedied and the consumption thereby reduced to 137 gallons per day.

Meter No. 13,882 was set February 28, 1881, and on April 1 was found to have registered at the daily rate of 6,634 gallons. A large leak was found under the building, and the consumption reduced to 600 gallons per day.

Meter No. 14046 was set April 2, 1881, on a four story block of two stores, and after running nine days, was found to be registering 4,283 gallons per day. Several leaking fixtures were found and repaired by the owner, and the consumption thereby reduced to 170 gallons per day.

Meter No. 14063 was set April 13, 1881, on a three story building of three stores, and immediately commenced registering 6,850 gallons per day. These premises were examined by the owner when the meter was set and everything found in proper order as far as known; when the excessive waste was found, a second examination was made, and a closet discovered in the basement, which had been set by a tenant, without the knowledge or consent of the proprietor. This closet was running and had been ever since it was set. This waste was stopped, and the consumption reduced to 90 gallons per day.

Meter No. 13738 was set April 15, 1881, on a service supplying a three story building of five stores, and immediately commenced registering the enormous amount of 17,644 gallons per day, although two large leaks were found and stopped before the meter was set. Further examination disclosed additional leaks; the repairing of which resulted in reducing the daily use to 442 gallons.

In all cases where meters were set, the proprietors were immediately notified to prevent waste, and nearly all the leaks discovered were from hitherto unsuspected sources.

In the six cases cited above, (and many more of similar character could be given,) there was running a total of 51,171 gallons per day, or 18,677,415 gallons per annum.

The reduction effected by these six meters, amounts to 48,851 gallons per day, or nearly 18,000,000 gallons per year.

In order to show still more clearly the results accomplished by the introduction of meters, in the matter of saving of water, the following table has been prepared.

The first column gives the meter number; the second column the number of gallons of water passing the meter daily when first set; the third, the number of gallons of water passing, after the pipes and fixtures had been put in proper condition.

The six cases mentioned above are included.

Meter No.	Daily flow when meter was set	Flow aft'r pipes repaired
13893	13,008	881
13874	8,580	255
14053	3,062	45
13882	6,634	600
14046	4,283	170
14065	8,550	645
13738	17,644	442
14063	6,850	90
13898	829	30
12929	496	70
13993	1,347	384
14037	2,896	870
14030	1,500	450
13490	690	75
12935	531	157
14035	750	30
13499	2,565	856
13887	2,752	137
13492	3,872	384
14038	3,589	1,155
14071	632	145
Total	91,060	7,871

The saving effected by these 21 meters, amounts to over 29,000,000 gallons per annum or over 6 per cent. of the total quantity of water pumped during the past year.

There have been 10 meters set on premises, which showed at first a total daily consumption of 97,930 gallons, or over 35,000,000 gallons per annum or over 7 per cent. of the total water pumped.

It is impossible at present to give the saving which can be effected on these 10 services, as a number are still wasting a large amount.

The water passing these 10 services, would amount, at the rate of 15 cents per 1,000 gallons, to $5,361.00 per year. or an average of $536.10 each. None of these services supply the largest consumers. The total annual water rents received from the 10 was $472.04 or an average of $47.20 each. The highest rate received was $85.56, and the smallest $11.00. Here are ten services running more than ten times the water to which they are entitled by the rates paid.

The conclusion drawn from our experience with meters is, that more than two-thirds of all the water pumped, is permitted to run to waste, and that the meter system of selling water is the only one which can prevent or remedy such a condition of affairs.

It is asked: "What of it? Suppose people do waste water, does not the interest account have to be paid, even if no water was used? Is not the only *real* cost of the water the value of the fuel used to pump it? What does it signify if it can be shown that 21 meters effect an annual saving of 6 per cent. of the annual pumpage? Why cannot we use as we please?"

A sufficient answer is, that our present supply of water is barely sufficient for our present needs, and that the danger of a water famine is imminent.

It costs thousands of dollars annually to pump this wasted water from which not the slightest benefit is derived.

If this waste is not checked, not only will it be necessary to secure as soon as possible an additional supply, but it will be also necessary to duplicate certain essential, costly portions of our water works system. Is the privilege of wasting water worth this price?

Experience with meters shows that they operate directly in the interest of the careful householder; that is, that it is cheaper for the consumer to use metered water, than to pay the schedule rates, provided his fixtures are kept in good repair. This is proven by our own experience as well as the experience of other cities that have adopted the meter system.

The following table illustrates a few of the many cases which might be mentioned.

Meter No	Daily con sumpt'n in gallons	Annual schedule rate paid	Annual Rate by Meter.	Meter No	Daily con sumpt'n in gallons	Annual Schedule rate paid	Annual Rate by Meter
14031	258	$41 20	$28 25	14044	78	$22 40	8 54
13868	152	26 00	16 64	4264	32	9 50	3 50
13880	234	43 88	25 62	13833	43	7 50	4 71
13876	90	37 32	9 85	13888	43	7 00	4 71
13874	51	26 00	5 58	13862	38	13 60	4 16
13881	354	62 00	38 76				

All the above meters are on business blocks. The fixtures are in proper repair and water is used for all purposes desired.

MAINS.

A serious accident happened to the force main on the morning of September 2.

The main was of 16 inch Wyckoff Patent Wood Pipe, and was laid through a deep ravine on a grade of about 1 in 5. The bottom and sides of this ravine were mainly of sand of varying degrees of fineness.

The water from a long length of graveled street had been permitted to discharge into the ravine, near the west bank of the reservoir, and a very heavy rain during the night precipitated so great a quantity of water into the same, that the sand was washed from under the force main, permitting the pipe to break apart.

The water was shut off as soon as possible after the accident, but so great was the force of the two 16 inch streams of water, that a large amount of damage resulted.

About 850 feet of the force main was blown out, an immense amount of sand and gravel washed down into the streets and lots below, and a large amount of property damaged by water, but fortunately without loss of life.

After due consideration of the matter, the Board decided to replace the wood pipe with iron, and as the sand had been washed out for a considerable depth below the grade line of the pipe it was decided to lay the new pipe upon an iron trestle, that should be founded in solid ground, and prevent the possibility of future settlement, or the danger of being undermined again by water.

For the trestle columns, 3 inch cast iron gas-pipe was selected and driven through the sand and gravel, in most cases into a bed of solid clay, which underlies the sand through the lower portion of the ravine.

An inclined pile driver was built, so arranged as to be readily handled, fitted with a cast iron hammer, weighing 196 pounds having a maximum fall of 12 feet.

Very few pipes were broken by the blows from the hammer, and it was found practicable to drive the pipes from 2 to 3 feet into the clay, and as far through sand as was desired.

The top of the pipe was capped with a cast iron corbel held in place by a lead joint, the corbels supporting cast iron saddles to which they were well bolted.

The bents thus formed were braced and tied with strap iron, held by bolts and cap screws.

The bents were placed 12 feet apart, and the saddle was so made as to hold a joint of lead, to afford an even bearing for the pipe.

The laying of the new main was completed December 1. The work of refilling portions of the street washed out has yet to be done.

Some expense has been incurred during the year in lowering mains in Barclay, Bronson and Ransom streets, in consequence of changes in the street grades.

The following table shows the number, location and cause of the various leaks in the mains during the year.

LEAKS ON DISTRIBUTION MAINS,

STREETS.	Size. Inch.	Kind of Pipe.	DATE	CAUSE.
Fountain	6	Pump log	May 10	Joint
Fountain	6	Pump log	" 19	Check
Scribner	8	Wyckoff	" 25,	Joint
N. Lafayette	14	"	" 27,	"
Canal	8	"	June 4	"
Summer	6	"	" 14	"
Fountain	6	Pump log	" 15	Check
Supply pipe	20	Stave	" 22	Cracks
Scribner	8	Wyckoff	" 23	Joint
Scribner	6	"	July 23,	Check
Fountain	6	Pump log	" 23,	Joint
W. Bridge	12	Wyckoff	" 28	"
Lyon	10	"	August 2	Knot hole
Lyon	10	"	" 5	"
Broadway	12	"	" 5	Joint
Scribner	6	"	" 6	"

LEAKS ON DISTRIBUTION MAINS. (Continued.)

STREETS	Size. Inch	Kind of Pipe.	DATE	CAUSE
W. Bridge	12	"	" 9	"
Scribner	8	"	" 13	"
Broadway	12	"	" 13	"
W. Bridge	12	"	" 14	"
Supply Pipe	20	Stave	" 18	
Scribner	6	Wyckoff	" 27	Check
Ottawa	12	Iron	" 31	Joint blown out
Scribner	8	Wyckoff	September 28	Joint
Broadway	12	"	October 11	"
Scribner	8	"	" 12	"
S. Division	12	"	" 13	"
Fountain	6	Pump log	" 15	Check
Supply Pipe	20	Stave	" 16	
Third	4	Wyckoff	November 4	Joint
Broadway	12	"	" 16	"
Plainfield Ave	8	Iron	January 6	Burst Pipe
Eighth	12	Wyckoff	" 11	Knot hole
E. Fulton	10	"	March 1	Joint
Scribner	8	Wyckoff	March 18	Joint
Scribner	8	"	" 26	"
Scribner	8	"	April 1	" pipe settled
Scribner	8	"	" 4	
Jefferson	4	"	" 7	"
Fountain	6	Pump log	" 11	Split
Bronson	6	Wyckoff	" 14	Joint
Scribner	8	"	" 18	"
Summer	4	"	" 27	"

The total number of leaks was 43 against 64 the previous year.

It will be seen that 12, or nearly 28 per cent. of the whole, were on the Scribner street line, which seems to show that poor material was used in the original work.

Several important extensions to the mains have been commenced during the year, the work on which is now in progress. They are as follows: a 12 inch line in Winter street, from W. Bridge street to W. Fulton street; an 8 inch line in W. Fulton, Gold, Watson and Straight streets from Winter street to Butterworth avenue, and an 8 inch line in Prescott street, Buchanan street and Wealthy avenue, from S. Division street to Summit street.

There has been appropriated for these extensions the sum of $12,602.20.

A 2 inch line was laid in Ransom street, from Bronson to Lyon streets. This line is claimed as a private line, although the sum of $45 was paid by the city towards the work. I understand that parties wishing to connect with this line, have to pay about $25 for the privilege, to the persons who claim to own it. I do not think it is good policy for the city to assist in the construction of private lines which are not exclusively the property of the city, and which may serve to prevent the laying of public lines, and thus do injustice to would-be consumers of water.

As illustrated by this case, a few persons may get the assistance of the city in laying a private line, prevent thereby for a long time the laying of a public line, and by charging all persons who make connections a price for tapping, get reimbursed for their original outlay, and possibly become possessed of a source of revenue.

The total length of water mains now laid, not including work under contract, is 22.28 miles; number of hydrants 235, number of valves 182.

Respectfully submitted,

A. C. SEKELL, Superintendent.

Collector's Report.

OFFICE OF THE BOARD OF PUBLIC WORKS,
May 2, 1881.

To the Honorable Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—I respectfully present the following report for the year ending April 30, 1881:

The number of services on the 1st of May, 1880, for which permits were issued were	862
Taps granted without permits,	20
Private mains connected with works,	16
Total,	898
Number of services put in the past year, for which permits were issued,	50
Private mains connected with works,	1
Total number of connections on May 1, 1881,	949
Number of services now cut off,	100
Number of services now open,	849

The receipts at this office for the year have been as follows:

From Water Rates,	$15,521.41
From Water Permits,	325.50
Total income from Water Works,	$15,846.91
There has also been received for labor and material,	96.38
From Sewer Permits,	81.00
Total receipts for the year,	$16,024.29
Cash on hand May 1, 1880,	438.25
	$16,462.54

Deposits have been made with the City Treasurer during the year, as follows:

To the credit of Water Works income fund,	$15,791.03
" " Water Works fund,	96.38
" " 1st District Sewer Fund,	58.50
" " 2nd " " "	22.50
Total deposits during the year,	$15,968.41
Cash on hand to balance,	494.13
	$16,462.54

Receipts from May 1, 1874, the commencement of collections, to May 1, 1880:

From Water Rates,	$59,604.71
From Water Permits,	4,606.23
From Sewer Permits,	333.00
From various sources, (as per last report)	943.41
Total	65,487.35
Receipts for the past year,	16,024.29
Total receipts to date,	$81,511.64

Deposits made from May 1, 1874, to May 1, 1880:

To the credit of Water Works Income Fund,	$64,640.20
" " " Fund,	264.90
" " 1st District Sewer Fund,	121.50
" " 2nd " " "	22.50
Total	$65,049.10
Deposits made the past year,	15,968.41
Cash on hand to balance,	494.13
Total	81,511.64

STATEMENT OF EXPENDITURES.

May 1, 1880 to May 1, 1881.

CONSTRUCTION OF WATER WORKS.

1. Pipe System.

Winter Street main,	$4,301.62

Prescott, Buchanan and Wealthy Avenue main,	648.00
Supply Pipe,	7,263.23
Lowering Pipe, &c,	283.84
	$12,496.69

2. Pumping House and Grounds.

Lumber,	$39.79

3. Meters.

New Meters and setting,	3,767.47

4. Additional Supply.

Printing report, analysis, &c.	374.66
Total paid on construction,	16,678.61
Paid previous to May 1, 1880,	404,296.01
	$420,974.62

MAINTENANCE AND OPERATION OF WATER WORKS.

1. Pumping.

Salary, Engineer,	$ 901.66
" Assistant Engineer,	900.00
" 3 Firemen,	1,543.75
Fuel,	3,728.31
Repairs to Pumping Machinery,	124.03
" Boilers,	80.91
" Boiler Arches,	25.30
" Engine House,	20.15
Supplies, (oil, Packing &c.,)	451.88
	$7,775.99

2. Office and Collecting.

Salary, Collector,	$ 675.00
Printing and Advertising,	4.25
Stamps and Stationery,	33.95
Freight, Fuel &c.,	45.65
	$ 758.85

3. SUPERINTENDENCE AND REPAIRS.

Salary, Superintendent,		$ 888.00
" Foreman of Repairs,		250.50
		$1,138.50

REPAIRS.

1. IRON PIPE.

Labor,	$27.85	
Material,	82.76	
		110.61

2. WYCKOFF PIPE.

Labor,	$201.57	
Material,	37.14	
		238.71

3. PUMP LOGS.

Labor,	$ 28.50	
Material,	3.27	
		31.77

4. SUPPLY PIPE.

Labor	34.00	
Material	26.85	
		60.85

5. HYDRANTS.

Labor,	101.03	
Material	112.40	
		213.43

6. METERS.

Labor,	13.10	
Material,	69.28	
		82.38

7. SUPPLY CREEKS.

Salary, Watchman,	112.00	
Labor,	138.20	
Material,	26.12	
		276.32

8. Service Connections.

Labor,	16.50	
Material,	56.85	
		73.35

9. Miscellaneous.

Tools,	87.53
	$2,262.95

Mason Street Force Main.

Repairs, provided for by special appropriation,	$ 2,770.65

Recapitulation.

Pumping,	$ 7,775.99
Office and Collecting	758.85
Superintendence and Repairs	2,262.95
Total paid for Maintenance and operation,	10,797.79
Mason Street Force Main repairs,	2,770.65
Paid Previous to May 1, 1880,	49,441.46
Total paid to date,	$63,009.90

Respectfully submitted,

FRED A. TWAMLEY, Collector.

Engineer's Report.

GRAND RAPIDS, MICH., May 1, 1881.

To the Honorable, the Board of Public Works of the City of Grand Rapids,— GENTLEMEN:

I have the honor to submit herewith my annual report of the work done by the pumping engines for the year ending April 30, 1881.

The machinery has been running on 365 days, making a total of time run 4,269 hours and 20 minutes, against 361 days, or 3,213 hours and 15 minutes run the previous year.

I am pleased to say, that the engines and boilers are in good repair, and working in a very satisfactory manner.

It will be seen by the following report that we have consumed more wood in proportion to the water pumped, than in previous years. This is owing in part, to an extra 15 lbs. pressure the pumps were subjected to, during three months of last fall, while the force main was undergoing repairs, and also to the poor quality of the wood, much of which was wet from exposure to the storms of early winter.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, and amount of wood burned. The estimated quantity of water pumped per revolution is 100 gallons.

MONTH.	Days Pumpd	Time Run. H. M.	No of Revolut'ons	Gallons water Pumped.	Cords of wood used	Cost of wood used
May	31	291—30	371,230	37.123,000	140¼	$217 38
June	30	296—35	393,872	39,387,200	144½	223 97
July	31	290 -10	396,915	39,691.500	153½	257 92
August	31	305—20	426,702	42,670,200	150	232 50
September,	30	398—55	386,890	38,689,000	173	268 15
October	31	400—05	392,100	39,216,000	162½	251 87
November	30	379—55	387,376	38,737,600	161¼	249 93
December	31	420—30	463,045	46,304 500	196¾	314 60
January	31	422—00	470,000	47,000,000	215¼	344 40
February	28	373—55	413.122	41,312,200	215	344 00
March	31	371—10	404 526	40,452,600	234½	375 20
April,	30	318—15	339,303	33,930,300	167¼	268 08
Total	365	4269—20	4,875,141	487,514,100	2114	$3338 12

Total cost of raising one million gallons into reservoir, $15.84

Total cost of fuel for raising one million gallons into reservoir, $6.82.

The running expenses for the year have been:

Engineers, Saleries,			$1,801 66
Firemen, "			1,548 75
Fuel			3,689 31
	Repairs.	Supplies.	
A. Leitelt Bros. & Co.,	$48 16	$153 96	$ 197 12
C. H. Southwick,		41 40	41 40
E. P. Thayer,		83 52	83 52
L. D. Putnam		20 75	20 75
Foster, Stevens & Co.,		4 50	4 50
Shriver, Weatherly & Co.	20 84		20 84
E. G. Studley,		1 80	1 80
Leonard & Ellis		188 80	188 80
Boston Belting Co.,	88 70		88 70

John Olson	25 80		25 80
Butterworth & Lowe,	70 85		70 85
			$7,722 80

Respectfully submitted,

DEMETRIUS TURNER,

Engineer of Pumping Machinery.

Report of City Surveyor.

City Surveyor's Office,
Grand Rapids, Mich., May 1, 1881.

To the Honorable Mayor and Common Council of the City of Grand Rapids,—GENTLEMEN:

I have the honor to submit herewith the annual report of improvements which have been conducted by the Board of Public Works during the past year.

STREETS.

The street improvements which have been completed during the year, are exhibited in the following table, which also shows the character and cost of each improvement, and also the street improvements now under contract and not completed.

Street improvements completed during the year ending April 30, 1881.

NAME OF STREET,	FROM	TO	KIND OF IMPROVEMENT.	LENGTH	COST.				CONTRACTORS.
					Construction.	Assm't &c	Total	Per Foot.	
Watson............	S. Front.......	Shepard.	Graded and Graveled..............	3,311 ft.	$ 2,242.59	$ 198.90	$ 2,441.40	74	Farr & White....
W. Fulton.........	S. Front.......	Shepard.	" " "	3,767 "	3,807 80	230.85	4,038.65	1 07	Farr & White....
Cypress...........	Fifth...........	North..........	" " "	5,878 "	5,550.00	228.55	5,778.55	98	Utes & Livingston.
S. Front...........	Allen	W. Bridge.....	Graded, graveled and gutters paved	1,204 "	2,252.40	126,45	2,378.85	1 97	A. Wiseman......
S. Front...........	Allen	Butterworth...	" " " " " Graded and Graveled............	900 " 1,993 "	8,111.00	209.05	8,320.05	2 87	C. Prange.........
Antoine............	S, Division.....	S. Ionia........	Graded, graveled and gutters paved	594 "	1,165.00	64.95	1,229.95	2 07	C. Prange.........
Ransom............	Lyon	Bronson.	" " " " "	537 "	1,853,00	71.21	1,924.21	3 58	Joel Collins.......
W. Bridge.........	Grand River...	Broadway.	Repaving, cedar bl'ks & cobble stone	1,041.80	1,888.30	88.23	1,976.53	1 89	Utes & Livingston
Gold..............	W. Fulton.....	Butterworth...	Graded and Graveled..............	1,234 ft.	1,002.00	70.35	1,072.35	87	C. Prange.........
W. Broadway......	W. Fulton.....	Butterworth...	" " "	1,337 "	1,397.00	52.35	1,449.35	1 09	Leonard & Waters.
Campau	Pearl	Lyon	Repairing		362.00	36.95	398.95	1 10	Joel Collins.......
E. Fulton..........	Jefferson	Union	Graveled and gutters paved.......	2,644 "	3,792.00	124.58	3,916.58	1 48	C. Prange.........

Street improvements commenced during the year and not completed.

Name of Street	From	To	Kind of Improvement.	Length	Estimated Cost.			Contractors.
					Construction.	Assm't &c	Total.	
Canal.............	E. Bridge......	N. City limits..	Cedar block repaving.............	7,959 ft.	$10,450 00	$ 1,100 00	$11,550 00	Utes & Livingston.......
Bronson & Crescent	Kent...........	N. Prospect....	Graded, graveled & gutters paved.	3,770 "	14,500 00	450 00	14,950 00	McBrian & Farr.........
Prescott..........	S. Division.....	Grandville Ave.	" " " "	2,072 "	4,945 00	175 00	5,120 00	C. Prange................
Madison...........	Plainfield......	North Ave.....	Graded...........................	1,965 "	1,960 00	125 00	2,085 00	A. Wiseman.............
N. Lafayette.......	E. Bridge......	Fairbanks.....	Graveled and gutters paved.......	1,718.6	1,841 64	128 36	1,970 00	Leonard & Condley......
N. Division........	Lyon...........	Bronson.......	Graded, graveled & gutters paved,	484 "	1,000 00	60 00	1,060 00	B. Livingston............
Veto...............	W. Division....	Shepard.......	Graded and Graveled..............	2,570 "	3,015 00	155 00	3,170 00	C. Utes..................
Kellogg............	Union..........	Packard.......	Graded, graveled & gutters paved.	766 "	974 00	66 00	1,040 00	A. Wiseman.............

SEWERS.

The total length of sewerage system is 20.033 miles of which there are of

Brick Sewers,	8.086	miles.
Glazed Pipe Sewers,	9.877	“
Cement “ “	0.480	“
Wood Sewers,	1,590	“
Total,	20.033	“

The following tables show the sewers completed during the year, with their location and cost, and also the sewers now under contract and not completed.

Sewers completed during the year ending April 30, 1881.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Manholes	Catchba's	Lampho's	Length in feet.	COST.			CONTRACTOR.
							Con-struct'n	Ass'mt &c.	Total.	
Fourth Street....	From 285 ft. W. of Broadway st. E. to Broadway st. Sewer........	16 in. x 24 in. Brick	1			353	$395 00	$ 48 71	$443 71	Utes & Livingston...
Fifth Street......	From 285 ft. W. of Broadway St. E. to Broadway Street Sewer........	12 in. glazed S. pipe	1			387	475 00	47 91	522 91	Joel Collins..........
Williams Street..	From 150 ft. E. of Summit st. E. to S. Ionia street Sewer........	12 " "	2	2	1	705	923 00	74 65	997 65	Joel Collins..........
First Street......	From 50 ft. W. of N. Front Street W. to sewer in Broadway Street........	12 " "	3	2		815	1500 00	77 59	1577 59	Joel Collins..........
E. Fulton Street.	From W. line of S. Prospect St., W. to 35 ft. W. of Lafayette Street........	12 " "	2	3		472	635 00	65 61	700 61	Joel Collins..........
In alley between Kent, Ottawa, E. Bridge and Hastings Sts...	From 75 ft. North of E. Bridge Street North to Hastings Street Sewer........	9 " "	1			467	550 00	47 75	597 75	Joel Collins..........
S. Ionia Street...	From 50 ft. South of E. Fulton Street to the Island Street Sewer........	9 " "	2			298	299 00	36 35	335 35	Joel Collins..........
In alley between S. Ionia and S. Spring St. from Cherry to Oakes	From 50 ft. North of Cherry Street North to Spring Street Sewer........	9 " "	2			422	453 00	40 51	493 51	A. Wiseman.........
Prescott Street ..	From 50 ft West of S. Ionia Street West to Prescott, Buchanan and 5th Avenue Sewer........	12 " "	1	2	1	606	828 00	65 20	893 20	Wiseman& Schneider
Second Street....	From 201 ft. West of Broadway east to Sewer in Broadway street........	16 in. x 24 in. Brick	1			267	367 00	44 55	411 55	Wiseman& Schneider
Lagrave Street..	Wealthy Avenue to Wenham Avenue........	12 in. glazed S. pipe	1	1		561	572 00	88 55	660 55	Joel Collins..........
Bank Street....	South line lot 8 Kent plat to 40 ft. South of East Bridge street........	9 " "	2			200	225 00	49 05	274 05	Joel Collins..........
Ransom&Brons'n	N. line Ransom st. from Lyon st. to Bronson st, E. in Bronson st. to N. Prospect st........	15 " "	5	9	1	1782	3273 48	222 85	3496 33	C. Prange............

Sewers completed during the year ending April 30, 1881. (Continued.)

NAME OF STREET.	LOCATION	SIZE AND KIND.	Manholes	Catchbn's	Lampho's	Length in feet.	COST.			CONTRACTOR.
							Con-struct'n	Assm't &c.	Total.	
Jefferson Street..	From 46 ft. N. of Chatham st. N. to W. Bridge st. sewer, and from 40 ft. S. of Chatham st. S. to Sibley st. sewer..............................	9 in. glazed S. pipe	5	4		1204	$ 999 18	$ 70 35	1069 53	Joel Collins..........
W. Broadway St.	From 75 ft. S. of W. Bridge st. S. to Sibley street sewer..	12 " " 9 " "	4	6		1000 223	1286 00	77 75	1363 75	A. Wiseman.........
Barclay Street...	From 75 ft. S. of E. Bridge st. S. to sewer in Bronson street	9 " "	1			439	467 00	56 71	523 71	Joel Collins..........
N. Prospect St...	From 150 ft. S. of Fountain st. S. to sewer in East Fulton street..................................	9 " "	2			657	535 00	68 66	603 66	Joel Collins..........

Sewers under contract and not completed.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Manholes	Catchba's	Lampho's	Length in Feet.	ESTIMATED COST.			CONTRACTORS.
							Con-struct'n	Assm't &c.	Total.	
Winter st. sewer extension in Broadway st...	In W. Bridge st. from Winter st. sewer to Broadway st. N. in Broadway st. to North st.........	12 in. glazed S. pipe	18	40		1410	$ 25,547	$1203 00	$ 26,750	McBrian & Farr.....
		20 x 33 in. brick....				1222				
		35 x 45 "				1311				
		41 x 53 "				1303				
		56 x 72 "				2804				
Seventh & Davis.	In Seventh st. from Broadway sewer to Davis st. N. in Davis st. to W. Leonard st...............	30 x 45 "	7	8		1330	15,775	725 00	16,500	C. Prange............
		40 x 52 "				1310				
		45 x 58 "				1550				
Kent, Newberry and Ottawa....	From 45 ft. N. of Bronson st. in Kent alley N. to Newberry st. E. in Newberry to Ottawa, N. in Ottawa st. to 100 ft. S. of Coldbrook st.........	12 in. glazed S. pipe	10	17		632	15,000	1900 00	16,900	Collins & Mathewson
		20 x 30 in. Brick....				716				
		24 x 26 "				552				
		28 x 42 "				988				
		32 x 48 "				1679				
		37 x 48 "				528				
Prescott, Buchanan & Fifth Ave.	From Jefferson Ave. W. in Fifth Ave. to Buchanan st. N. in Buchanan st. to Prescott st. W. in Prescott st. to Grandville Ave. thence westerly along creek to Oakland Ave...................	27 x 41 "	11	7		950	22,900	1600 00	24,500	J. C. Murray.........
		31 x 46 "				662				
		32 x 42 "				644				
		43 x 56 "				1576				
		55 x 71 "				1218				
		Box Sewer.........				650				
		Open Ditch........				500				

The total estimated length of the streets now opened in the city is 180.76 miles, of which there are

Graded and paved with wood	0.15	miles.
Graded and paved with wood and stone	4.08	"
Graded and paved with stone	0.96	"
Graded, graveled and gutters paved	24.99	"
Graded and graveled	28.68	"
Graded	8.85	"
Unimproved	68.15	"
Total,	180.76	"

CRESCENT PARK.

A contract for the grading of Crescent park was awarded by the Board on November 8, 1880, which provided only for the removal of the surplus sand, and the shaping of the surface for the reception of soil and sodding. A contract was awarded on April 28, 1881, for covering the sand with soil or loam, the construction of gravel walks and for sodding.

These contracts will be completed during the coming season.

The contract prices are, for grading $650.00 for soiling and sodding, $1500.00.

The following is the cost of the street and sewer improvements which have been brought to completion during the year, including incidental expenses:

Street improvements	$ 34,925 51
Sewerage	14,965 41
Total cost of completed work	49,890 92
Paid by Board on incomplete work	50,944 52
Total	100,835 44
Paid on above prior to May 1, 1880	15,166 04
Leaves amount paid during year	$ 85,669 40

Respectfully submitted,

A. C. SEKELL, City Surveyor.

Inventories, May 1. 1881.

PIPE, ETC., AT PUMPING STATION.

26 Pieces, 6 inch, 12 feet long.
13 “ 8 “ 12 “
8 “ 10 “ 12 “
17 “ 12 “ 12 “
1 “ 14 “ 12 “
5 “ 16 “ 12 “
1 “ 20 “ 12 “
1 “ 4 “ 7 “
1 “ 6 “ 8 “
1 “ 6 “ 10 “
1 “ 6 “ 7 “
1 “ 8 “ 6 “
2 “ 8 “ 7 “
1 “ 8 “ 3 “
1 “ 10 “ 6 “
6 “ 12 “ 11 “
1 “ 12 “ 8 “
1 “ 12 “ 6 “
1 “ 16 “ 4 “
1 “ 16 “ 5 “
1 “ 20 “ 11 “
7 4 inch Sleeves.
4 6 “ “
1 8 inch Sleeve.
2 10 “ “
2 12 “ “
2 14 “ “
2 16 “ “
2 20 “ “
1 Reducer hub ends 16 to 12.
1 Lot 16 inch Wyckoff pipe, about 400 feet.
1 Lot of old Wyckoff pipe, small sizes.
1 20 inch Flange Valve.
1 6 inch Valve.
1 6 inch Valve body.
1 Valve box cover, (complete.)
1 “ “ (incomplete.)
5 Ludlow Hydrants, (old.)
2 4 inch Hydrant bases.
1 Hydrant base plate.
1 12 inch Plug.
2 6 inch Pump log thimbles.
1 Lot old iron.

STOCK AND TOOLS AT REPAIR SHOP,

2 New Valves for Mathew hydrants.
2 Iron stems for Lowry hydrants.
2 Stand pipes for Lowry hydrants,
13 Brass stems for Lowry hydrants.
13 Rubber valves for Lowry hydrants.
3 Castings for Lowry hydrant valves.
5 Calking Irons.
2 Cut-off Saws.
1 Rip Saw.
1 Cross-cut Saw.
1 Compass Saw.
2 Pipe Cutters.
1 Cutter Stop and 4 Dies.
1 Claw Hammer.
2 Sledge Hammers.
2 Files.
1 Ice Pick.

5 Castings for Lowry hydrants
3 Brass valves for Ludlow hydrant.
5 lbs of springs for Lowry hydrant drips.
2 Glands.
1 4 in. valve stem with wheel
3 4 " "
2 6 " "
2 8 " "
4 10 " "
1 12 " "
1 14 " "
1 16 " "
3 heads for valve stems.
1 valve box cover.
2 gross screws.
60 feet 1½ inch rope.
40 feet 1 inch rope.
13 thimbles for Wyckoff pipe.
2 lbs Oakum.
4 bolts for hydrant extensions
2 Bundles shingles.
15 lbs Solder.
50 lbs old lead.
16 lbs nails.
½ bushel charcoal.
5 gallons coal tar varnish.
5 Iron bands.
8 ½ in. corp'n cocks w'd pipe
44 ⅝ " " "
32 ¾ " " "
21 ½ " " Iron pipe
44 ⅝ " " "
12 ¾ " " "
15 1 " " "

NEW METERS:

41 Ball & Fitts Rotary Rubber
40 " " Bronze
5 Crown Meters.

OLD METERS:

9 Ball & Fitts, Piston.
1 " Rotary Rubber.
1 " " Bronze,
1 Worthington.
85 Meter boxes.
3 Oil cans.
3 Lanterns.
1 Pair Dividers.
1 Wire Snip.
1 Pocket Level.
4 Shovels.
5 Picks.
1 Large Clamp.
2 Small Drill Clamps.
1 Bench Vise.
3 Pails.
2 Large Valve Wrenches.
1 Lowry Hydrant Wrench.
1 Post " "
1 Short Cut-off Key.
1 Hydrant Head.
1 Pair Rubber Boots.
1 Washer Cutter.
1 Knife.
2 Screw Drivers.
1 Hatchet.
1 Jack Plane.
2 Pumps.
1 Light Derrick.
3 Pulleys.
2 Small Brushes.
2 Hoes.
1 Maul.
2 Wrenches.
1 Scraper,
2 Saw Benches.

1 Large Monkey Wrench.
1 Brace.
1 Ratchet Brace.
4 Tapping drills.
18 Tapping Augers.
2 Drilling Ratchets.
5 Taps for Iron Pipe.
1 Cold Chisel.
1 Wood Chisel.
1 Punch.
1 Calking Hammer.
1 Earth Auger.
1 Testing Pump.
1 Stove and pipe.
1 Fire pot.

2 Baskets.
150 feet Tape Line.
1 Snow Shovel.
40 Screws for lowering pipe.
1 pair Hose Couplings.
1 Gasket Iron.
1 Lot of old Brass.
1 “ “ Iron.
1 “ “ Rubber.
1 “ “ Hose.
1 “ “ Iron pipe fittings.
1 “ “ Bolts and Nuts.
1 “ Rubber Packing.
1 “ Hoop Iron.
1 “ Gasket Yarn.

STOCK AND TOOLS AT PUMPING WORKS.

205 Cords of slab wood.
75 lbs. of Waste.
25 gallons of Valvoline Oil.
25 “ Machine Oil.
1½ “ Castor Oil.
8 “ Kerozene Oil.
1 “ Lard Oil.
25 lbs. Boiler Compound.
3000 lbs of old Cast Iron.
1 Set Pump Valves for New Engine.
5 Pump Valves for Old Engine.
2 Foot Valves.
37 feet 1½ Hose and Nozzle.
8 Brooms.
1 Lantern,
1 Flue Scraper.
1 Boiler Scraper.
4 Fire Hooks.

4 Long Boiler Scrapers.
1 Stove poker and shovel.
2 Long Valve Wrenches.
4 Long Common Wrenches.
1 Long Socket Wrench.
1 Short “ “
12 Spanners.
2 Large Monkey Wrenches.
4 Small “ “
2 Door Mats.
2 Scoop Shovels.
2 Long handle Shovels.
1 Common Hoe.
2 Fire Pokers.
1 Hand Saw.
1 Dirt Pick.
1 2½ inch Hose Nozzle.
1 ¼ “ “ “
1 Hatchet.
1 Bit Stock.

22 feet of 2½ inch Gas Pipe.
8 “ ½ “ “
6 “ ¼ “ “
16 “ 1½ “ “
14 “ 1¾ “ “
13 “ 2¾ “ “
14 “ 1 “ “
1 1 Gallon Jug.
2 10 Gallon Oil Cans.
2 5 “ “
2 2 “ “
2 1 “ “
2 12 “ “
2 1 pint Oil Cans.
1 Squirt “
2 Spittoons.
4 yards Canvas.
1 Vise.
2 Water pails.
1 Step Ladder.
2 long Ladders.
1 short “
6 Chairs.
1 Dust Pan.
1 Stove and pipe.
3 Hand Lamps.
5 Wall Lamps.

1 Brass Oil Pan.
1 1¼ inch Auger.
4 Small Bits.
1 Packing Hook.
6 Cold Chisels.
4 Old Files.
1 Steam Gauge.
4 Glass Tubes for Air Chamber.
1 “ “ Boiler.
3 2½ inch Old Globe Valves.
2 2 “ “ “
1 1½ “ “ “
2 1 “ “ “
2 ¾ “ “ “
1 1 inch Check Valve.
2 ¼ “ “
2 ¾ “ “
1 2½ inch Brass Coupling.
1 ¾ “ Iron “
2 2 “ “ “
1 3 “ “ “
5 1 inch Plugs.
7 2½ inch Flanges.
3 2½ inch Tees.
1 12 inch Eye Bolt.
1 Lot of Old Bolts.

FURNITURE &c., IN OFFICE.

1 Safe.
1 Counter.
1 Stove.
1 Desk.
1 Standing Desk.
3 Tables.
16 Chairs.
1 Letter Press and Stand.
1 Map of Water Mains.

1 Portfolio Water Maps.
1 Case of Stationery.
1 Case of Reports.
5 Cuspidores.
1 Waste Basket.
1 Water Crock
1 Feather Duster.
1 Broom.

ANNUAL REPORT

—OF THE—

BOARD OF PUBLIC WORKS

—AND—

CITY SURVEYOR,

—OF THE—

CITY OF GRAND RAPIDS,

For the year ending April 30, 1882.

Grand Rapids:
O. H. GODWIN, BOOK AND JOB PRINTER.
1882.

ANNUAL REPORT

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1882.

REPORT

—OF THE—

BOARD OF PUBLIC WORKS,

—TO THE—

Common Council of City of Grand Rapids,

TRANSMITTING THE REPORTS OF THE

Superintendent, Collector & Engineer

—OF THE—

WATER WORKS

For the Fiscal Year ending April 30, 1882.

—ALSO THE—

ANNUAL REPORT OF THE CITY SURVEYOR.

Grand Rapids:
O. H. GODWIN, BOOK AND JOB PRINTER.
1882.

BOARD OF PUBLIC WORKS

GEORGE W. THAYER, President.
(TERM EXPIRES MAY, 1882.)

O. L. HOWARD.
(TERM EXPIRES MAY, 1882.)

A. D. PLUMB.
(TERM EXPIRES MAY, 1883.)

WILDER D. STEVENS.
(TERM EXPIRES MAY, 1884.)

F. B. GILBERT.
(TERM EXPIRES MAY, 1884.)

OFFICERS:

A. C. SEKELL, City Surveyor and Sup't Water Works.
FRED A. TWAMLEY, Clerk and Collector.
THOS. J. WILLARD, Assistant Collector.
DEMETRIUS TURNER, 1st Engineer at Pumping Works.
GEORGE E. KIRK, 2d Engineer at Pumping Works.
S. M. BARROWS, TIMOTHY ROSE and GEO. H. BARROWS, Firemen.
JOHN VANAMBERG, Foreman of Repairs.
MICHAEL SCHMIDT, Watchman.

REPORT OF THE BOARD.

BOARD OF PUBLIC WORKS,
Grand Rapids, Mich., May 1, 1882.

To the Honorable, the Mayor and Common Council of the City of Grand Rapids:—GENTLEMEN:

The Board of Public Works have the honor to submit herewith, their report for the year ending April 30th, 1882, accompanying which, will be found the annual report of A. C. Sekell, as City Surveyor, and as Superintendent of Water Works; of Fred A. Twamley, Collector of Water Rates; and of Demetrius Turner, Engineer in charge of the Pumping Works.

These several reports give in detail, useful and all necessary information in relation to practical operations in the several departments named, for the past year; also the present condition of each.

The report of the City Surveyor shows the number of miles of improved streets in the city, the kind of improvements made thereon, the number of miles of streets unimproved, together with the number, character of work done, and cost of improving streets during the past year; also, street improvements now under contract. Said report also presents a statement of the amount of brick, pipe, cement and wooden sewers already constructed, giving location and cost of same, and of those now under contract. It gives valuable information in relation to other public improvements completed, and now in progress.

The report of the Superintendent of Water Works embodies valuable information, to which your attention is particularly invited.

The problem of a more abundant and better water supply for this city, is yet to be solved. The number of consumers of city water is steadily increasing; an addition of 13 per cent. having been made during the past year. The calls for an extension of the water mains in various parts of the city are becoming frequent, and are often pressing and persistent. Any considerable extension of the water mains with a proportionate increase of consumers will render an additional water supply imperative. The question of furnishing our rapidly growing city with an abundant supply of the best water that its geographical position will permit, and of largely extending the water mains to meet the requirements of the public for purposes of more extended fire protection and domestic use, together with that of providing the necessary funds to meet the cost of the same, must soon demand the careful attention not alone of those who are by law charged with the large expenditure of money that will be required to provide for the public necessities in the direction named, but of every tax paying citizen as well.

Aside from the question of water supply it may be well to state that there can be no legitimate material extension of water mains until action shall be taken by the city looking to the making of further loans to provide money to defray the expense of such extensions.

The Board have not funds at their disposal to extend water mains even for a single block, excepting as they are from time to time provided by the Council.

From May 1, 1877 the Council have replenished the water works fund by borrowing from other funds to meet the cost of duplicate boiler and engine at pumping house, supply pipe, additional meters, extension of water mains and other smaller items of construction, upwards of $60.000 The funds depleted by these transfers to the water works fund have been replenished by direct taxation. To what extent the Council may be willing to continue this practice may be determined by the exigences that may from time to time be brought to their attention.

Upon representations made by the Board to the Council about December, 1880, the Council caused to be transferred to the water works fund the sum of $5,000 which enabled the Board to increase the number of water meters in use from 90 to 280 with most satisfactory results.

As stated by the Superintendent, "the effect of these meters in preventing waste is very apparent. The approximate daily consumption for each open service for the year ending May 1, 1881 was 1600 gallons, while during the past year it has averaged 1280 gallons, representing a reduction of 20 per cent.

There were used during the year ending May 1, 1881 2114 cords of wood for pumping, while during the past year there have been used 1663 cords. The actual amount saved, as shown by the Engineer's report amounting to $612.05. In other words, water has been pumped last year for supplying 905 services for $615.05 less than it cost to pump water for 834 services the year previous."

The receipts from water rates for the year ending May 1, 1882, exceed those of the previous year by $4,391.62, and this, notwithstanding that a reduction in the rates charged for metered water was made April 1, 1881, which amounted to more than $1,000 on the 90 meters previously in use, aggregating a saving in a single year equal to the sum expended for meters; more than verifying the statements made by the Board to the Council as to the benefits to be derived by an increase in the number of meters then in use.

The supply of water for the past year, notwithstanding the unusually dry summer of 1881 was much more abundant than in 1880. This is to be attributed partly to a saving effected by the use of meters, and partly to a saving secured by the laying of a new iron supply pipe in place of the leaky wooden one that required a sewer to take off its waste.

As will be seen by the report of the Superintendent, "a 12 inch line of water pipe was laid in East Fulton street from Division street to Waterloo street, and in West Fulton street from Winter street to South Front street. Proposals were received by the Board for laying a 12 inch line across Grand river at Fulton street to connect these last named lines, but as the lowest bid was largely in excess of the estimated cost, the Board decided to execute the work by day labor under the direction of the Superintendent of Water Works. The work of crossing the river has been successfully accomplished, but owing to delays in securing a right of way the work of connecting the east end of the river pipe with the main at Waterloo street was stopped on account of high water, leaving about 260 feet yet to be laid.

The expense so far incurred on this work is $2,181.50 or over $6,500 less than the lowest bid received."

It gives the Board pleasure to state that this great saving of expenditure is due to the skill and ability of Mr. A. C. Sekell, City Surveyor and Superintendent of Water Works, who exceeded the most sanguine expectations of the Board in successfully accomplishing this difficult work, in a manner original with himself, showing in a marked degree, his fitness for the position he fills with high credit to himself, and to the great advantage of the City he serves.

For these, and other reasons of like force and merit not necessary to be enumerated here, the Board, in the discharge of their duty to the public interest, with entire unanimity, most cheerfully united in a communication to the Mayor, setting forth therein important facts for his consideration, and asking him to renominate Mr. Sekell to the position he has so ably filled. The Board take this occasion, in this public manner, to express its approbation of the action of the Mayor in renominating, and of the Council in confirming such nomination, notwithstanding the efforts made to prevent it, thereby emphasizing a policy indicating that considerations of political expediency should be made subservient to the public interest.

The report of the Superintendent gives a tabular statement showing on what streets repairs to the water mains have been required, and the kind of pipe, wood or iron, wherein defects have been discovered. The total miles of water mains now laid is stated as 24 and 67-100; number of fire hydrants 260; number of valves 156.

The report of Mr. Fred A. Twamley, the Collector of Water Rates and Clerk of the Board is well worthy of a careful examination. It gives very full information of all matters relating to receipts and disbursements in each branch of the water department.

The gross receipts for the year are given as $20,238.53. The gross expenditures, covering cost of repairs and operating expenses as $12,071.16, showing an excess of receipts over expenditures of $8,167.37. The previous year shows an excess of receipts over expenditures of $5,049.12.

The expenditures of the present year are greater than those of the previous year by $1,273.37, notwithstanding a saving of over $600 in fuel at the pumping house. This is owing to a large increase in cost of repairs on Wyckoff pipe, considerable improvements about the settling basin, and other similar items, together with some increase of office expenses.

Mr. Twamley has performed the duties of his position in an intelligent and most satisfactory manner.

The report of Mr. Demetrius Turner, Engineer in charge at the pumping works gives in detail the work done under his supervision, showing, when compared with former years, satisfactory results.

The Board avail themselves of this opportunity to convey to the Mayor and Council their high appreciation of the consideration they have given to all official matters to which the Board have had the honor to invite their attention. They trust there may arise no impediment to a continuation of the most satisfactory relations existing between the two bodies, to each of whom, are committed important public interests, that may be best promoted by harmonious action and a proper regard for the prerogatives of each.

Respectfully submitted,

GEO. W. THAYER,
WILDER D. STEVENS,
F. B. GILBERT,
A. D. PLUMB,
O. L. HOWARD,

Board of Public Works.

SUPERINTENDENT'S REPORT.

OFFICE OF SUPERINTENDENT OF WATER WORKS,
Grand Rapids, Mich., May 1, 1882.

To the Honorable Board of Public Works:—GENTLEMEN:

I have the honor to submit herewith the following annual report of the condition of the Grand Rapids Water Works for the year ending April 30, 1882.

RESERVOIR.

The reservoir is in excellent condition. No expenditures have been made during the year, and there were none made the year previous.

The recommendations contained in the report of last year suggesting some improvements in the grounds and upon the reservoir banks might be repeated here. A comparatively small sum invested in this direction would not be without a corresponding benefit.

SETTLING BASIN AND SUPPLY CREEKS.

Considerable work has been done at the settling basin during the year as recommended in the last annual report.

The old wooden dams which were built, one to raise the water of Coldbrook creek to such height as would admit of filling the basin, the other to act as a protection to the pipe leading from the basin to the pump house have been entirely rebuilt, and in a much better manner than they were originally, being much wider and stronger.

The old plank outlet from the settling basin has also been removed and a substantial brick culvert substituted which discharges below the lower dam.

The improvements made, together with the completion of the iron supply pipe, mention of which was made in the last report, enable a much greater depth of water to be maintained in the basin than was practicable before, and much improvement in the quality of water pumped has been the result.

The basin inlets have yet to be repaired or rebuilt as may be thought best.

Some improvements and repairs are also necessary at the gate house, the most important of which will be the construction of an arrangement which will permit only the water from near the surface to be drawn off, instead of from the lower muddy stratum as at present.

With the completion of the work suggested coupled with careful management I am of the opinion that we shall be able to furnish a much better quality of water than has hitherto been practicable.

No additional steps have been taken in the matter of increased supply.

The amount of water pumped in July and August of last year was 81,434,200 gallons, an amount about one per cent. less than was pumped for the same period the previous year.

The season was unusually dry, and the amount pumped was about 80 per cent. of the total yield of the creeks, no water passing the dam except for a few hours in the early morning.

On May 1, of last year there were 849 open services connected with the works, and the amount of water pumped during May was 40,905,800 gallons, the amount of water daily used per service averaging over 1550 gallons.

There are now 962 open services connected with the works, an increase of 13 per cent. over one year ago.

Should the coming season find the creeks as low as they were last year it is likely that summary measures will be necessary to prevent waste in order to avert a water famine.

The quality of the water furnished is of necessity likely to deteriorate with the continued increase of population in the creek valleys. Large and increasing numbers of cattle now find pasturage in this section, and while no serious results may as yet be apparant, the popular prejudice against city water for domestic uses is not likely to continue much longer without substantial foundation.

In this connection I would respectfully recommend that some hydraulic engineer of repute be employed to examine our proposed sources of additional supply, to review the work embodied in the report submitted by myself on this subject in June, 1880, and to submit to your honorable body the result of his investigations and conclusions, to the end that some definite plan for future action be determineed upon.

HYDRANTS AND VALVES.

The hydrants and valves are in good condition. All the hydrants were examined before the commencement of winter, and all the Lowry hydrants were provided with new springs for opening the drip valves.

But little trouble with hydrants was had during the year, none whatever from frost. The Ludlow hydrants were originally opened by means of a five sided nut many of which became so worn that they could only be used with difficulty, and hydrant wrenches of two different kinds had to be carried by the fire department. To oviate this, large square nuts similar to those upon the Mathews hydrants have been prepared and placed upon all the Ludlow hydrants.

All the hydrants and valve boxes which were in plank have been examined during the year. A number of these were found in a dangerous condition, and were repaired or replaced with Bingham and Morgan's patent boxes. It is likely that many more will have to be replaced during the coming season. One Ludlow hydrant not in use has been reset on a private main at the west bank of the Canal in Erie street.

SERVICE CONNECTIONS.

During the year permits have been issued for 110 service connections, or over double the number issued the year previous. There were also five connections put in for a temporary purpose, for which no permits were issued.

There were also connected with the mains six private lines.

The total connections now number 1,070, of which 108 are cut off and 962 open.

METERS.

Continued experience with meters justifies the policy of the Board in bringing them into general use.

There are now owned by the City 305 meters of which there are set and in operation 280, as follows:

Ball & Fitts Rotary	196
Worthington	7
Crown	9
Ball & Fitts, Piston	68
Total,	280

There are in the shop as follows:

Ball & Fitts, Rotary	11
Worthington	1
Crown	2
Ball & Fitts, Piston	11
	25

There are also in use two Hartford meters which are running on trial.

The effect of these meters in preventing waste is very apparent.

The approximate daily consumption for each open service for the year ending May 1, 1881 was 1600 gallons, while during the past year it has averaged 1280 gallons, representing a reduction of 20 per cent.

There were used during the year ending May 1, 1881 2114 cords of wood for pumping, while during the past year there have been used 1663 cords, the actual amount saved as shown by the engineer's report amounting to $612.05.

In other words, water has been pumped last year for supplying 905 services for $615.05 less than it cost to pump water for 834 services the year previous.

MAINS.

Several important extensions to the mains have been completed during the year, all of which were laid with cast iron.

They are as follows: a twelve inch line in Winter street from W. Bridge street to W. Fulton street; an eight inch line in W. Fulton street from Winter street to Gold street, south in Gold street to Watson street, west in Watson street to Straight street, and south in Straight street to

Butterworth avenue; an eight inch line in Prescott street from S. Division street west to Buchanan street, north in Buchanan street to Wealthy avenue, and west in Wealthy avenue to Summit street; a six inch line in S. Ionia street from Cherry street to Wealthy avenue; and a twenty inch line in Coldbrook street from the settling basin to the pump house to replace the stave pipe originally laid. A part of the work in Coldbrook street was executed in a very imperfect manner, and a number of leaks on the line have resulted in consequence.

A twelve inch line was also laid in E. Fulton street from Division street to Waterloo street, and in W. Fulton street from Winter street to S. Front street.

Proposals were received by the Board for laying a twelve inch line across Grand River at Fulton street to connect these last named lines, but as the lowest bid was largely in excess of the estimated cost the Board decided to execute the work by day labor, under the direction of the Superintendent of Water Works.

The work of crossing the river has been successfully accomplished, but owing to delays in securing a right of way the work of connecting the east end of the river pipe with the main at Waterloo street was stopped on account of high water, leaving about 260 feet yet to be laid.

The expense so far incurred on this work is $2,181.50 or over $6,500 less than the lowest bid received.

The following table shows the number, cause and location of the various leaks on the mains during the year.

LEAKS ON DISTRIBUTION MAINS.

Name of Street.	Kind of Pipe.	Size. Inch.	DATE.	CAUSE.
Stocking	Iron	8	May 5	Split
Barclay	Wyckoff	14	" 7	Joint
E. Fulton	"	10	" 24	"
Canal	"	8	June 3	Knot hole
S. Division	"	12	" 3	Joint
Bronson	Pump log	6	" 7	"
N. Lafayette	Wyckoff	14	" 7	"
Clancy	Pump log	6	" 18	"
Wealthy Ave	Iron	8	" 20	Pipe burst
Lyon	Blow-off valve	6	" 21	
Broadway	Wyckoff	12	" 22	Joint
Buchanan	Iron	8	" 25	Pipe burst
S. Division	Wyckoff	12	" 29	Joint
Third	"	4	July 1	"
Allen	"	8	" 23	"
S. Division	"	12	" 25	"
Ottawa	"	16	" 28	"
E. Fulton	"	10	" 30	"
Waterloo	"	8	Aug. 2	Knot hole
Scribner	"	8	" 13	Joint
E. Fulton	"	10	" 16	"
Waterloo	"	8	" 22	"
W. Bridge	"	12	" 27	"
W. Bridge	"	12	Sept. 3	"
Waterloo	"	8	" 9	"
Waterloo	"	8	" 16	"
Fountain	Pump log	6	" 28	Rep'd wi'h iron
Waterloo	Wyckoff	8	" 29	Knot hole
E. Fulton	"	10	Oct. 5	Joint
Lyon	"	10	" 7	"
Ottawa	"	16	" 31	"
Canal	"	8	Nov. 3	"

LEAKS ON DISTRIBUTION MAINS. (Continued.)

Name of Street.	Kind of Pipe.	Size. Inch.	DATE.	CAUSE.
Fulton	"	10	" 8	Check
Canal	"	8	" 9	"
Bronson	Pump log	6	" 25	Split
"	" "	6	" 26	"
Scribner	Wyckoff	8	" 30	Joint
E. Fulton	"	10	Dec. 10	"
N. Canal	"	8	" 17	"
Coldbrook	Iron	20	" 16	"
"	"	20	" 24	"
"	"	20	" 26	"
"	"	20	" 30	"
"	"	20	Feb. 8, 1882	"
Lyon	Wyckoff	10	March 6	"
Cherry	Iron	8	" 16	Plug
Scribner	Wyckoff	8	" 24	Joint
"	"	8	April 10	"
S. Division	"	12	" 13	"
Ottawa	Iron	12	" 18	"
Broadway	Wyckoff	12	" 22	"
Scribner	"	8	" 26	"
"	"	8	" 26	"
"	"	8	" 27	"
Jefferson	"	4	" 27	Knot hole

The total number was 55 against 43 the previous year, and 64 the year before that.

The total length of water mains now laid is 24.67 miles; number of fire hydrants, 260; number of valves, 156.

Respectfully submitted,

A. C. SEKELL, Sup't W. W.

COLLECTOR'S REPORT.

OFFICE BOARD OF PUBLIC WORKS,
May 1, 1882.

To the Honorable Board of Public Works of the City of Grand Rapids:—GENTLEMEN:

I respectfully present the following report for the year ending April 30, 1882.

The number of services on the 1st of May, 1881 for which permits were issued were...........	912
Taps granted without permits,................	20
Private mains connected with works,............	17
Total........	949
Number of services put in the past year for which permits were issued...........	110
Taps granted without permits, (special).........	5
Private mains connected with works,....	6
Total number of connections on May 1, 1882,	1,070
Number of services now cut off,...............	108
Number of services now open.................	962

The receipts at this office for the year have been as follows:

From Water Rates,......................	$19,579.03
From Water Permits,....................	659.50
Total income from Water Works,........	$20,238.53

There has also been received, from contractor's fine	40.00
From T. F. Richards, ½ cost of Jackson street improvement,	277.00
From Sewer Permits,	115.50
From contractor's forfeit on bid,	10.00
Total receipts for the year,	$20,681.03
Cash on hand May 1, 1881,	494.13
	$21,175.16

Deposits have been made with the City Treasurer during the year, as follows:

To the credit of Water Works Income Fund,	$20,349.05
“ “ “ Contingent Fund,	40.00
“ “ “ Jackson street grading,	277.00
“ “ “ General Fund,	10.00
“ “ “ First District Sewer Fund,	81.00
“ “ “ Second District Sewer Fund,	34.50
Total Deposits during the year,	$20,791.55
Cash on hand to balance,	383.61
	$21,175.16

Receipts from May 1, 1874, the commencement of collections, to May 1, 1881.

From Water Rates,	$75,126.12
From Water Permits,	4,931.73
From Sewer Permits,	414.00
From various sources, (as per past reports).	1,039.79
Total,	$81,511.64
Receipts for the past year	20,681.03
Total receipts to date,	$102,192.67

Deposits made from May 1, 1874 to May 1, 1881.

To the credit of Water Works Income Fund,	$80,431.23
" " " Water Works Fund,	361.28
" " " First Distrist Sewer Fund,	180.00
" " " Second District Sewer Fund,	45.00
Total,	$81,017.51
Deposits made the past year,	20,791.55
Cash on hand to balance,	383.61
Total,	$102,192.67

STATEMENT OF EXPENDITURES.

May 1, 1881 to May 1, 1882.

CONSTRUCTION OF WATER WORKS.

1. Pipe System.

West Fulton, Watson, Gold and Straight street mains,	3,812.90
Winter street main,	938.94
Prescott, Buchanan and Wealthy ave. main,	2,176.82
Supply Pipe,	1,467.39
Main under river,	4,130.14
E. and W. Fulton street main	6,646.16
South Ionia street main,	1,545.58
Miscellaneous,	321.15
	$21,039.08

2. Pumping House and Grounds.

Lumber,	21.12

3. Meters.

New Meters and setting,	1,284.39
Total paid on construction,	22,344.59
Paid previous to May 1, 1881,	420,974.62
Cost of Works to date,	$443,319.21

MAINTENANCE AND OPERATION OF WATER WORKS.

1. Pumping.

Salary, Engineer,	1,200.00
" Assistant Engineer,	900.00
" 1st. Fireman,	600.00
" 2nd. "	600.00
" 3rd. "	547.50
Fuel,	2,803.50
Repairs to Pumping Machinery,	80.42
" " Boiler Arches,	63.89
" " Engine House,	9.11
Supplies, (oil Packing, &c.,)	299.03
	$7,103.45

2. Office and Collecting.

Salary, Collector,	675.00
" Assistant Collector,	360.12
Printing and Advertising,	52.94
Stamps and Stationery,	53 70
	$1,141.76

3. Superintendence and Repairs.

Salary, Superintendent,	300.00
" Foreman of Repairs,	720.00
	$1,020.00

REPAIRS.

1. Iron Pipe.

Labor,	34.45	
Material,	11.82	
		46.27

2. Wyckoff Pipe.

Labor,	382.82	
Material,	124.96	
		507.78

3. Pump Logs.

Labor,	22.00	
Material,	5.15	
		27.15

4. Supply Pipe.

Labor,	252.60	
Material,	42.43	
		295.03

5. Valves.

Labor,	66.72	
Material,	79.87	
		146.59

6. Hydrants.

Labor,	122.42	
Material,	55.42	
		177.84

7. Meters.

Labor,	120.07	
Material,	25.15	
		145.22

8. Settling Basin.

Labor,	182.26	
Material,	67.25	
		249.51

9. Supply Creeks.

Salary, Watchman,	226.00	
Labor,	250.29	
Material,	93.21	
		569.50

10. Service Connections.

Labor,	69.19	
Material,	468.38	
		537.57

11. Miscellaneous.

Tools,...	81.09	
Blowing off..	22.40	
		103.49
		$3,825.95

Recapitulation.

Pumping,...	7,103.45
Office and Collecting,.............................	1,141.76
Superintendence and Repairs,..................	3,825.95
Total paid for maintenance and operation...	12,071.16
Paid previous to May 1, 1881,.................	63,009.90
Total Paid to date,...........................	$75,081.06
Income for the year,...............................	$20,238.53
Cost of maintenance and operation,...........	12,071.16
Excess of Receipts over Expenditures,........	$8,167.37
Income for the past year,........................	20,238.53
Income for the year ending May 1, 1881,...	15,846.91
Increase in Receipts,.......................	$4,391.62

Respectfully submitted,
FRED A. TWAMLEY,
Collector.

ENGINEER'S REPORT.

Grand Rapids, May 1, 1882.

To the Honorable, the Board of Public Works of the City of Grand Rapids:—GENTLEMEN:

I have the honor to submit herewith my annual report of the work done by the pumping engines for the year ending April 30, 1882.

The machinery has been running on 356 days, making a total of time run 3,815 hours.

I am pleased to say that the engines and boilers are in good repair, and working in a very satisfactory manner.

It will be seen by the following report that we have consumed 451 cords less wood, aud pumped 65,325,100 gallons less water than is shown by last years report.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, and amount of wood burned.

The estimated quantity of water pumped per revolution is 100 gallons.

MONTH.	Days run	Time run. H. M.	No. of Revolut'ns.	Gallons water pumped.	Cords wood used.	Cost wood used.	Price per cord
May	30	363—35	409,058	40,905,800	145¼	$232 40	$1 60
June..	28	290—05	330,947	33,094,700	123½	197 60	1 60
July	30	330—00	384,519	38,451,900	137½	220 00	1 60
August	31	376—05	429,823	42,982,300	151	241 60	1 60
September...	30	339—15	395,105	39,510.500	138	227 70	1 65
October.......	31	295—50	320,723	32,072,300	128¾	212 43	1 65
November...	30	285—25	312,364	31,236,400	133½	220 27	1 65
December ...	29	290—00	321,635	32,163,500	133	219 45	1 65
January......	29	368—35	343,279	34,327,900	144	237 60	1 65
February.....	28	292—55	316,205	31,620,500	144	237 60	1 65
March	30	305—35	346,521	34,652,100	148½	245 02	1 65
April...........	30	277—40	311,711	31,171,100	136	224 40	1 65
Total...........	356	3815—00	4,221,890	422,189,000	1663	$2716 07	....

Total cost of raising one million gallons into reservoir, $16.12. 52-100.

Cost of raising one million gallons one foot, $0.10. 75-100.

Cost of fuel for raising one million gallons into reservoir, $6.43 36-100.

Cost of fuel for raising one million gallons one foot, $0.04 28-100.

The running expenses have been:

Engineers, Salaries,................	$2,100.00	
Firemen, "	1,747.50	
Fuel,...	2,575.80	
		6,423.30

	Repairs.	Supplies.	
A. Leitelt,	$19.74	$58.40	$78.14
E. P. Thayer,		41.90	41.90
L. D. Putnam,		16.60	16.60
Foster, Stevens & Co.,	1.31	8.56	9.87
Shriver, Weatherly & Co.,	7.85	40	8.25
E. G. Studley,		15.20	15.20
Leonard & Ellis,		89.80	89.80
John Olson,	63.89		63.89
Chase & Munson,	2.00		2.00
S. G. Preston,		34.93	34.93
Fred Maybury,		10.00	10.00
Mich. Iron Work,	14.23		14.23
Total,	$109.02	$275.79	$6,808.11

Respectfully submitted,

DEMETRIUS TURNER,

Engineer Pumping Machinery.

REPORT OF CITY SURVEYOR.

CITY SURVEYOR'S OFFICE,
Grand Rapids, Mich., May 1, 1882.

To the Honorable Mayor and Common Council:—GENTLEMEN:

I have the honor to submit herewith the annual report of improvements conducted by the Board of Public Works during the past year:

STREETS.

The total estimated length of the streets now opened in the city is 132.97 miles, of which there are

Graded and paved with wood,	0.15	miles
Graded and paved with wood and stone	4.03	"
Graded and paved with stone,	0.96	"
Graded, graveled and gutters paved,	26.71	"
Graded and graveled,	28.79	"
Graded,	8.76	"
Unimproved,	63.57	"
Total,	132.97	

The following tables show the street improvements which have been completed during the year, the character and cost of each improvement, and also the street improvements now under contract:

STREET IMPROVEMENTS COMPLETED DURING THE YEAR ENDING APRIL 30, 1882.

NAME OF STREET.	FROM.	TO.	KIND OF IMPROVEMENT.	LENGTH.	CONTRACT PRICE.	ESTIMATED INCIDENTALS.	TOTAL A'T	Per foot	CONTRACTORS.
Canal	E. Bridge	N. city limits	Roadway repaved with cedar blocks	7,959 ft.	$10,450.00	$1,100.00	$11,550.00	1 45	Utes & Livingston
Bronson & Cresce't A	Kent	N. Prospect	Graded, graveled and gutters paved	3,770 "	14,500.00	450.00	14,950.00	3 96	McBrian & Farr
Prescott	S. Division	Grandville Ave	" " " " "	2,072 "	4,945.00	175.00	5,120 00	2 47	C. Prange
Madison	Plainfield	North Ave	Graded	1,365 "	1,960 00	125.00	2,085.00	1 52	A. Wiseman
N. Lafayette	E. Bridge	Fairbanks	Gutters paved and graveled	1,718.60	1,841.64	128.36	1,970.00	1 15	Leonard & Condley
N. Division	Lyon	Bronson	Graded, graveled and gutters paved.	484 ft.	1,000.00	60.00	1,060 00	2 19	B. Livingston
Veto	W. Division	Shepard	Graded and graveled	2,570 "	3,015.00	155 00	3,170.00	1 23	C. Utes
Kellogg	S. Union	Packard	Graded, graveled and gutters paved	766 "	974.00	66.00	1,040.00	1 34	A. Wiseman
Blakeley Ave	S. Division	S. Lafayette	" " " " "	1,500 "	3,140.00	160 00	3,300.00	2 20	B. Livingston
Charles	Cherry	Wealthy Ave	" " " " "	1,359 "	2,973.00	127.00	3,100.00	1 54	A. Wiseman
Monroe	N Spring	E. Fulton	Roadway repaved with cedar blocks	407 "	915.35	84.65	1,000.00	2 46	Leonard & Condley
Maple	S. Division	Jefferson Ave	Graded, graveled and gutters paved	913 "	1,599.00	101.00	1,700 00	1 86	Prange & Hurlbut
N. Ionia	Newberry	Walbridge	E gutter paved	1,335 "	550.85	149.15	700.00	52	L. D. Leonard
Center	Blakeley Ave	Fifth Ave	Graded, graveled and gutters paved	1,541 "	3,250.00	150.00	3,400.0	2 21	B. Livingston
N. Ionia	Coldbrook	E. Leonard	" " " " "	830 "	2,443.90	116.10	2,560.00	3 08	Mathewson & Leonard

STREET IMPROVEMENTS COMMENCED DURING THE YEAR AND NOT COMPLETED.

NAME OF STREET.	FROM.	TO.	KIND OF IMPROVEMENT.	LENGTH.	CONTRACT PRICE.	ESTIMATED INCIDENTALS.	TOTAL A'T	CONTRACTORS.
S. Ionia	E. Fulton Cherry	Cherry Wealthy Ave	Graded and paved with cobble stone Roadbed paved with cobble stone.	1,226 ft. 1,244 "	$6,900.00	$350.00	$7,250.00	C. Utes
Bank	E. Bridge	Squires' Alley	Graded and graveled	278 "	421.39	28.61	450.00	I. B Mathewson
Jackson	Marion	W. city limits	" " "	595 "	534.00	2 00	554.00	A. Wiseman
Henry	Cherry	Fifth Ave	Graded, graveled and gutters paved	3,971 "	10,113 00	312.00	10,425.00	A. & W. Wiseman

SEWERS.

Action has been taken during the year looking to an important improvement in the sewer system. Nearly all of the sewers on the east side of the river have their outlets on the east bank, and for several years the nuisance resulting therefrom has increased, while various plans for its abatement have been suggested and discussed.

At a session of the Council on May 16, '81 Alderman Griswold, as Secretary of the Committee of the Whole made a verbal report, recommending that the matter be referred to the Board of Public Works.

On May 30 the Board submitted a report to the Council which contained the following:

"To effectually and permanently abate the existing nuisance on the Island Co.'s addition, is an old and difficult problem; the Board have the subject under consideration, but have not yet perfected any plan or recommendations to submit to your honorable body in relation to the same; but hope to do so at as early a day as the matters to be considered will permit."

On July 23, the City Surveyor submitted a report to the Board suggesting two plans for securing the desired results. This report was as follows:

To the Honorable Board of Public Works:—GENTLEMEN.

In the matter of plans and estimates of cost for abating the nuisance on the east side of the river below Pearl street, caused by the discharge of the public sewers, I respectfully submit the following:

Nearly all that part of the city lying east of the river, and bounded on the north by Coldbrook street; northeast by the watershed line of the Coldbrook Creek valley, east by the City limits, and south by Fourth avenue, is drained by sewers having their outlets at the river bank, near the Grand Rapids & Indiana Railroad bridge.

The northern portion of the district described, finding an outlet through the Bridge and Lyon street sewer, which discharges into the covered channel near the foot of Lyon street; the central portion flowing through the Monroe street sewer, which also discharges into the covered channel in Pearl street, while the southern and southeastern portions drain through the Fulton and Washington street sewer which finds an outlet at the foot of Fulton street. The covered channel into which discharge the main sewers in Lyon and Pearl streets as above indicated is known as the Butterworth tail race, and below Pearl street it is called the Island Co.'s sewer, and through it in addition to the contents of the sewers is discharged a certain amount of waste water from the east side canal.

This channel at its outlet has a flat bottom of timber or plank, which is 10 feet wide, the sides are of rubble masonry which supports a brick arch, the distance from the crown of the arch to the floor being 7 feet. The floor of this channel at its outlet is below ordinary low water.

The present terminus is near the South line of Louis street, and from this point the contents flow through an open canal a few hundred feet, passing under the railroad at Ferry street, and then turning at nearly right angles and flowing west to the river.

At low water the contents of the channel and the Washington street sewer flow for several hundred feet exposed to the sun and wind before emptying into the water of the river, and the sewage after entering the river is to some extent blown against the east shore, there to remain and decompose.

A considerable part of the drainage district mentioned is at present without sewerage and many of the buildings on the lines of the sewers built are at present without house drainage, and hence a continued increase of the nuisance complained of may be expected as new sewers are built and additional house drains connected.

The river at the points spoken of is between six hundred and seven hundred feet wide and from two to three feet deep in the deeper portions during periods of low water.

Manifestly the complete removal of the sewage to some unobjectionable point of discharge will furnish a satisfactory solution of the questions under examination.

Two plans are herewith submitted having in view the complete removal of the sewage from the present points of discharge.

The first contemplates the construction of an intercepting sewer from near the corner of Lyon and Canal streets southerly along the route shown on the accompanying plan to the outfall at Wealthy avenue, the sewer receiving on its way the contents of the Monroe street and the Fulton and Washington street sewers.

This sewer to be constructed to carry only the sewage proper or the dry weather flow, leaving the flood water of storms to be discharged through the present outlets; its outlet to be carried below low water, and some distance out from the shore line. This plan would result in the removal of the sewage to a point one-half mile below the present outfall of the Fulton street sewer; and as the sewage would be discharged under water and at some considerable distance from the shore, it is not likely that annoyance to property in the neighborhood would result.

The second plan has for its object the discharging of the sewage into the main channel of the river at the points nearest or directly opposite the present outlets of the main sewers.

To secure this result an intercepting sewer would commence in Lyon street near Canal street, thence running south in Canal street to Pearl street where the contents of the Monroe and Pearl street sewers would be received, thence west in Pearl street to the river bank. This intercepting sewer would be of brick and would discharge its contents at the river bank into a receiving chamber from which an iron pipe would convey the sewage to said channel. The discharge of the Fulton and Washington street sewer would in a similar manner be conveyed to the middle of the river.

The amount or volume of the sewage to be dealt with as an important factor, having to do with questions of size of sewer, and consequently of cost, and also with the advisability of discharging the sewage in the river immediately opposite the present sewer outlets.

Whatever water is used in a dwelling leaves it as sewage the animal excreta forming about one-sixtieth of its bulk.

In addition to this is the refuse from stables, manufactories, markets, laundries, and waste liquids of all kinds; amounting to nearly the same as house drainage.

Sixty gallons daily per individual is a legitimate measure of a complete water supply, forty gallons of which is sewage proper, the remaining twenty gallons being a fair allowance for the water used for other purposes, but which may enter the sewers, and therefore may be treated as sewage.

Sixty gallons daily per individual may therefore represent the greatest amount of sewage that we may have to contend with, and as one-half of the daily flow of sewage is discharged in eight hours the maximum discharge may be taken at three and three-quarters gallons per hour for each individual.

The population within the drainage district under consideration is not far from 15,000.

Suppose it increases to 25,000 then 1,500,000 gallons per day may be taken as the maximum sewage to be expected and 93,750 gallons per hour as the greatest flow.

A smooth pipe having an internal diameter of eighteen inches and a fall of six feet per mile will discharge this amount.

In regard to the success or failure of this second plan, we should consider first, the relative volumes of sewage and river water, and second the breadth, direction and velocity of current in the river; the questions to consider being "would the sewage if discharged in mid-channel be so diluted as to become inert, and would the more solid portions be carried by the current beyond the point of producing harm?"

So far as the question of relative volume is concerned, I think there can be but one conclusion.

As has been shown, the maximum volume of sewage to be dealt with is not likely to exceed 1,500,000 gallons per day, although the entrance of ground water into the sewers may make their dry weather flow somewhat greater.

The amount of water flowing in the river during ordinary low stages is nearly if not quite 1,000,000,000 gallons per day. During the unprecedented low water in September, 1879, its flow exceeded 600,000,000 gallons per day.

Providing that the sewage becomes well mixed soon after its discharge, each gallon of sewage would in times of extreme low water be diluted with 400 gallons of river water, and usually with very much more.

There can be no doubt that any dilution approaching this will render the sewage perfectly inert so far as its ability to create a nuisance is concerned.

In regard to the danger of the more solid portions of the sewage finding a lodgment against the river banks, my observations lead to the opinion that no difficulty need be apprehended from this source.

The breadth of the river and velocity of the current are such that I think none of the contents of the sewers would reach the shores until they had passed below the settled portion of the city.

It has often been suggested that the extension of the covered channel or the Island Co.'s Sewer, would provide a remedy for the evils now existing.

An objection to this may be found in the cost which would be excessive, but objections of a much more serious character exist.

To extend this sewer to Fulton street, would simply unite the discharge of the sewers which is now somewhat separated, and while it might to a .certain extent mitigate the evils now felt in the vicinity of the jail, it would increase the difficulty in the vicinity of Fulton street, and hence still further extensions would be required. The greatest objection to this course is found in the fact that this sewer has a wide flat bottom and a high arch, and that this bottom is at present lower than ordinary low water in the river.

While these conditions are very proper for a tail race they are in the highest degree objectionable for purposes of sewerage.

It is especially desirable that sewage should be carried to the point of discharge in the least possible time and before decomposition of the sewage commences. If the sewer should be extended, say three-fourths of a mile, to a point of safe discharge or even to the outlet of the Fulton street sewer, the bottom would be substantially level, and consequently the current would be very slow at the best, while every increase in volume of river water or rise in its surface would stop the current entirely. The result of this would be the formation of sewage deposit, which by decomposition would fill the sewer with pestilent gas, most difficult to remove; this sewer gas would be carried back into the sewer system, if the lower end of the channel was open to the wind, as it is at present, and if the end was closed then the gas would be forced back through the openings offering the least resistance, with every increase of temperature and with every increase in the volume of contained sewage.

At the end of a period of no great duration, I am of the opinion that the bottom of this sewer would be found covered with a reeking mass of decomposing sewage most difficult to remove, and most harmful in its effects. It is more than probable that the evils thus created would in reality be of more danger to the community then those we now seek to mitigate.

I estimate the cost of the main intercepting sewer, having its outfall at the foot of Wealthy avenue and receiving the dry weather flow of the Bridge and Lyon street sewers, the Monroe street sewer and the Fulton and Washington street sewer, at $22,000, and the cost of two iron pipe outlets discharging near the middle of the river, one receiving the contents of the Bridge and Lyon street sewer and the Monroe street sewer, the other providing an outlet for the Fulton and Washington street sewer, at $9,000.

Respectfully submitted,
A. C. SEKELL,
City Surveyor.

This report and the general plan accompanying it was duly considered and the President of the Board requested to transmit the same to the Council, and to recommend the carrying out of the cheaper plan.

The reasons for advising the cheaper plan were substantially as follows:

While there could be no doubt of the complete success of the more expensive scheme, it was believed that the cheaper one of delivering the sewage in or near the main channel of the river would prove equally satisfactory, at least for a number of years.

Again, considerable of the work required would be common to both plans and hence, in the event of failure, there would be but little loss, which would be mainly in the cost of the iron pipe outlets.

No further action in the matter was taken until Sept. 23, when the Committee on Ways and Means presented in their annual estimate of amounts to be raised by taxation, an item,

"For repairs and improvements at mouths of Washington and Fulton street sewers, as per estimate of Board of Public Works, 9,000."

Subsequently the Council adopted the resolutions necessary to enable the Board to proceed with the work.

Plans for the same are now in process of preparation and it is believed that the work will be successfully completed during the coming season.

The total length of the sewerage system is 22.572 miles of which there are of

Brick sewers,	10.239 miles
Glazed pipe sewers,	10.142 "
Cement " "	0.480 "
Wood sewers,	1.711 "
Total,	22.572 "

The following tables show the sewers completed during the year, with their location and cost, and also the sewers now under contract:

SEWERS COMPLETED DURING THE YEAR ENDING APRIL 30, 1882.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Manholes.	Catch-basins.	Length in feet.	Contract price	Estimated Incident's	Total.	CONTRACTORS.
Kent alley, Newberry and Otta'a	From 45 ft. N. of Bronson St. in Kent alley, N. to Newberry St., E. in Newberry to Ottawa St., N in Ottawa St. to 100 ft. S. of Coldbrook St.	12 in. glazed S pipe 20x30 in. brick..... 24x26 " " ...... 28x42 " " ...... 32x48 " " ...... 37x48 " "	10	17	632 716 552 988 1679 528	$15000 00	$1200 00	16200 00	Collins & Mathewson...
Prescott, Buchan'n and Fifth Ave....	From Jefferson Ave. W. in Fifth Ave to Buchanan St., N. in Buchanan St. to Prescott St., W. in Prescott St. to Grandville Ave., thence westerly along creek to Oakland Ave.	27x41 in. brick...... 31x46 " " ...... 32x42 " " ...... 43x56 " " .. 55x71 " " .... Box sewer............. Open ditch...........	11	7	950 662 644 1576 1218 650 500	22900 00	1600 00	24500 00	J. C. Murray...............
Eleventh.............	From 650 ft. W. of Broadway St. in Eleventh St., E. to sewer in Broadway St.	16x24 in. brick......	1	1	700	669 96	220 04	890 00	L. Schneider ....
Goodrich.............	From 65 ft. W of S. Division, W. in Goodrich St to sewer in S. Ionia st.	9 in. glazed S. pipe	2	2	558	565 00	75 00	640 00	A. Wiseman...............
Third..................	From 167 ft. W. of Broadway St. E. to sewer in Broadway St.	12 " " pipe.....		2	207	245 00	40 00	285 00	Joel Collins...............
Fourth.................	From N. Front to sewer in Broadway St.	16x24 in brick......	3	5	865	1890 00	250 00	2140 00	L. Schneider...............
W. Leonard.........	From E. line Hamilton St. to sewer in Broadway St....	22x33 " "	1	2	291	475 00	225 00	700 00	L. Schneider...............

SEWERS UNDER CONTRACT AND NOT COMPLETED.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Manholes.	Catch-basins.	Length in feet	Contract price	Estimated incident'ls	Total	CONTRACTORS.
Winter St. sewer exten'n in Broad way............	In W Bridge St. from Winter St sewer to Broadway St. N in Broadway St. to North St	12 in glazed pipe 20x30 in brick 35x45 " " ...... 41x53 " " ..... 56x72 " "	18	40	1410 1222 1311 13 3 2804	$25547 00	$1203 00	26750 00	McBrian & Farr........
Eleventh & Davis..	In Seventh St from Broadway St. sewer W. to Davis St., N. in Davis St. to W. Leonard St........................	30x45 " " ...... 40x53 " " ... 45x52 " "	7	8	133 1310 1550	15775 00	725 00	16500 00	C. Prange................
Seventh	From Alpine Ave to sewer in Davis St.........................	20x30 " " ...... 12 in. glazed pipe	2	4	650 38	1212 00	238 0	1450 00	Mathewson & Leonard.
S. Division and Wealthy Ave.....	In S. Division St. from S. line Wenham Ave., N. to Wealthy Ave., E in Wealthy Ave to Cass St.					7200 00	800 00	8000 00	J. Collins ....
Madison Ave.........	From 75 ft. N. of State St to sewer in Washington St	6 in. glazed S pipe	1		532	364 00	36 00	400 00	J C. Murray ....
Alley between Ottawa and Ionia from Bronson to E. Bridge St.....	From 50 ft. S. of E. Bridge St. to Bronson St. sewer.....	9 " " "	1		520	560 00	40 00	600 00	J. Collins................
Alley between Ottawa and Ionia from Lyon to Bronson......	From 75 ft N. of Lyon St. to sewer in Bronson St.......	9 " " "	1		455	470 00	40 00	510 00	L. Schneider............
Springfield Ave.....	From Fremont St. to Stocking St., in Stocking St. to Fifth St sewer......	12 in glazed pipe... 9 " " " ...	1		136 600	591 00	39 00	630 00	J. C. Murray...........
N Front	From 15 ft. S of Eighth St. to Fourth St. sewer.	12 " " "	3	7	1296	1400 00	70 00	1470 00	J Collins.. ....
S. Lafayette	From 276 ft. S. of Cherry St to Cherry St. sewer.........	9 " " " ...	1		324	248 00	30 00	278 00	L Schneider............
N. Division.........	From 50 ft S. of E. Bridge St to Bronson St. sewer.....	9 " " " ...	1		531	290 00	20 00	310 00	J. Collins.. ....

CRESCENT PARK.

The contracts for the improvement of Crescent Park mentioned in the last report, have been completed.

The contract last awarded on April 23, 1881, provided for covering the entire surface of the park, except walks, with soil or loan, the sodding of the same and the construction of gravel walks where required; the work was executed in a satisfactory manner, resulting in rendering attractive what had hitherto been a most unsightly locality.

The cost of grading the park was $680.00, the cost of soiling and sodding $1,500.00.

A contract for constructing a stone stairway was awarded by the Board on April 23, 1881, but the failure of the Council to approve the same prevented any further action.

IRON BRIDGE.

On September 12, 1881, the Common Council adopted a resolution declaring the construction of one span of iron bridge to connect the east end of the main part of the Bridge street bridge, with the east bank of Grand river, also the necessary abutments, approaches and walks, a necessary public improvement.

The specifications for the bridge and also for the abutment were soon after submitted to the Board, and adopted; proposals were advertised for and received. No bid for the stone work of a satisfactory character was obtained and, in consequence the construction of this part of the work was deferred until the present season.

The contract for the bridge was awarded October 29, 1881, to the Wrought Iron Bridge Co., Canton, Ohio, for $1,640.00.

The contract provides for a clear span of 36 feet, clear width of roadway 22 feet, width of sidewalks 8 feet each, and the several members are so proportioned as to admit a live road of 100 pounds per square foot over the entire surface of the roadway and walks without straining the iron to exceed one-fifth of its ultimate strength.

All the iron for the work is now on the ground ready for erection upon the completion of the abutment.

The work of grading the approach and preparing a suitable roadbed will be proceeded with as rapidly as possible.

The following is the assessed cost of the several improvements which have been brought to completion during the year exclusive of expenditures relating to Water Works construction:

Street improvements,	$56,705.00
Sewerage,	45,355.00
Crescent park,	2,180.00
Total	$104,240.00

Respectfully submitted,
A. C. SEKELL,
City Surveyor.

INVENTORIES, MAY 1, 1882.

PIPE, ETC., AT PUMPING STATION.

16 pieces, 4 in. 12 feet long.
29 " 6 " 12 " "
5 " 8 " 12 " "
6 " 10 " 12 " "
17 " 12 " 12 " "
1 " 14 " 12 " "
5 " 16 " 12 " "
7 " 20 " 12 " "
1 " 20 " 2½" "
1 " 20 " 6½" "
2 " 20 " 10 " "
1 " 12 " 8 " "
2 " 12 " 6 " "
5 " 12 " 11 " "
2 " 12 " 4 " "
2 " 12 " 3 " "
1 " 12 " 2 " "
1 " 10 " 2½" "
5 " 8 " 6 " "
1 " 8 " 4 " "
5 " 6 " 9 " "
4 " 6 " 3 " "
4 " 6 " 2 " "
2 " 6 " 1 " "
2 New Hydrants.

6 4 inch Sleeves.
10 6 " "
13 8 " "
1 10 " "
2 12 " "
2 14 " "
2 16 " "
2 20 " "
1 reducer hub ends 16 to 12.
1 Lot of 16 inch Wyckoff pipe, about 400 feet.
1 Lot of old Wyckoff pipe, small sizes.
1 20 inch Flange Valve.
1 6 inch Valve body.
6 Valve box covers, (complete.)
7 Valve box covers, (incomplete.)
4 Ludlow Hydrants, (old.)
1 4 inch Hydrant base.
1 Hydrant base plate.
1 12 inch Plug.
2 6 in. Pump log thimbles.
1 Lot old iron.

STOCK AND TOOLS AT REPAIR SHOP.

1 New Valve for Mathew Hydrant.
2 Iron stems for Lowry Hydrants.
2 Stand pipes for Lowry Hydrants.
11 Brass stems for Lowry Hydrants.
11 Rubber valves for Lowry Hydrants.

3 Castings for Lowry Hydrant valves.
7 Calking Irons.
2 Cut-off Saws.
1 Rip Saw.
1 Cross-cut Saw.
1 Compass Saw.
2 Pipe Cutters.
1 Cutter Stop and 4 Dies.
5 Taps.

2 Claw Hammers.
2 Sledge Hammers.
2 Files.
2 Ice Picks
5 Castings for Lowry Hydrants.
3 Brass valves for Ludlow Hydrants.
2 ℔s of springs for Lowry Hydrant drips.
2 Glands.
1 4 in. valve stem with wh'l
12 4 “ “
2 6 “ “
2 8 “ “
4 10 “ “
1 12 “ “
1 14 “ “
1 16 “ “
3 Heads for valve stems.
1 Valve box cover.
60 feet 1½ inch rope.
40 feet 1 inch rope.
13 Thimbles for Wyckoff pipe.
4 Bolts for Hydrant extensions.
1 Bundle shingles.
20 ℔s Solder.
50 ℔s Lead.
40 ℔s Nails.
½ Bushel charcoal.
5 Gallons coal tar varnish.
8 Iron bands.
40 ½ in. corp. cocks w. pipe
15 ⅝ “ “ “
68 ¾ “ “ “
24 ½ “ “ Iron pipe
36 ⅝ “ “ “
6 ¾ “ “ “
10 1 “ “ “

NEW METERS.

3 Ball & Fitts Rotary.
2 Crown Meters.

OLD METERS.

11 Ball & Fitts Piston.
8 “ Rotary.
1 Worthington.
2 Oil cans.
6 Lanterns.
1 Pair Dividers.
1 Pocket Level.
25 Shovels.
8 Picks.
1 Large Clamp.
2 Small Drill Clamps.
1 Bench Vise.
6 Pails.
2 Large Valve Wrenches.
1 Lowry Hydrant Wrench
1 Post “ “
4 Cut-off Street Keys.
1 Hydrant Head.
2 Pair Rubber Boots.
1 Washer Cutter.
2 Screw Drivers.
1 Hatchet.
1 Jack Plane.
3 Pumps.
1 Light Derrick.
3 Pulleys.
2 Small Brushes.
1 Maul.
2 Wrenches.
1 Scraper.
2 Saw Benches.
30 Shut-off Boxes.
1 Pair Pipe Tongs.
1 Pipe Wrench.
1 Large Monkey Wrench.
2 Small “ “
2 Braces.
6 Tapping Drills.
19 Tapping Augers.
1 Extension Bit.
1 Drilling Ratchet.

3 Cold Chisels.
1 Wood Chisel.
2 Punches.
2 Calking Hammers.
1 Machinest's “
1 Testing Pump.
1 Fire pot.
2 Baskets.
36 feet Tape Line.
1 Snow Shovel.
40 Screws for lowering pipe
1 Pair Hose Couplings.

2 Gasket Irons.
1 Lot of old Brass.
1 “ “ “ Iron.
1 “ “ “ Rubber.
1 “ “ “ Hose.
1 “ “ “ Iron pipe fittings.
“ “ “ Bolts and nuts
1 Lot Rubber Packing.
1 “ Hoop Iron.
1 “ Gasket Yarn.
1 Stove and Pipe.

STOCK AND TOOLS AT PUMPING WORKS.

181¼ Cords of slab wood.
80 ℔s of Waste.
5 Gallons Valvoline Oil.
25 “ Machine Oil.
1 “ Castor Oil.
4 “ Kerosene Oil.
150 ℔s Boiler Compound.
½ Set Pump Valves for New Engine.
2 Pump Valves for Old Engine.
37 ft. 1½ Hose and Nozzle
24 feet of Steam Hose and Couplings.
3 Brooms.
7 Mops.
1 Lantern.
1 Flue Scraper.
1 Boiler Scraper.
4 Fire Hooks.
1 4 inch Steam Flue Blower.
4 Long Boiler Scrapers.
1 Stove poker and shovel.
2 Long Valve Wrenches.
4 Common Wrenches.
1 Long Socket Wrench.
1 Short Socket Wrench.

12 Spanners.
2 Large Monkey Wrenches.
4 Small Monkey Whenches.
1 Door Mat.
2 Scoop Shovels.
2 Long handle Shovels.
1 Common Hoe.
2 Fire Pokers.
1 Hand Saw.
1 Dirt Pick.
1 Garden Rake.
1 2½ inch Hose Nozzle.
1 ¼ “ “ “
1 Bit Stock.
22 feet of 2½ inch Gas Pipe
8 “ “ ½ “ “
16 “ “ 1½ “ “
14 “ “ 1¾ “ “
13 “ “ 2¾ “ “
1 1 Gallon Jug.
2 10 Gallon Oil Cans.
2 5 “ “ “
2 2 “ “ “
2 1 “ “ “
2 1 Pint Oil Cans.
2 Squirt Oil Cans.

2 Cuspidors.
4 Yards Canvas.
1 Vise.
3 Water Pails.
1 Step Ladder.
2 Long Ladders.
1 Short "
6 Chairs.
1 Dust Pan.
1 Stove and Pipe.
3 Hand Lamps.
5 Wall Lamps.
1 Brass Oil Pan.
1 1¼ inch Auger.
4 Small Bits.
1 Packing Hook.
6 Cold Chisels.
6 Files.
1 Steam Guage.

4 Glass Tubes for Air Chamber.
1 Glass Tube for Boiler.
3 2½ in. old Globe Valves
2 2 " " " "
1 1½ " " " "
2 1 " " " "
2 ¾ " " " "
1 1 inch Check Valve.
1 ¼ " " "
2 ¾ " " "
1 2½ inch Brass Coupling
1 ¾ " Iron "
2 2 " " "
1 3 " " "
2 1 inch Plugs.
7 2½ inch Flanges.
3 2½ inch Tees.
1 12 inch Eye Bolt.
1 Lot of Old Bolts.

FURNITURE, &c., IN OFFICE.

1 Safe.
1 Counter.
1 Stove.
1 Desk.
1 Telephone.
1 Standing Desk.
3 Tables.
16 Chairs.
1 Letter Press and Stand.

1 Map of Water Mains.
1 Portfolio Water Maps.
1 Case of Stationery.
1 Case of Reports.
4 Cuspidores.
1 Waste Basket.
1 Water Crock.
1 Feather Duster.
6 Brooms.

ANNUAL REPORT

OF THE

BOARD OF PUBLIC WORKS

TO THE

Common Council of the City of Grand Rapids,

Transmitting the Reports of the

SUPERINTENDENT, COLLECTOR AND ENGINEER

OF THE WATER WORKS

FOR THE FISCAL YEAR ENDING APRIL 30, 1883.

ALSO THE

ANNUAL REPORT OF THE CITY SURVEYOR.

GRAND RAPIDS, MICH.:
ISAAC S. DYGERT, AGENT, PRINTER AND BINDER,
1883.

BOARD OF PUBLIC WORKS.

GEORGE W. THAYER, President.
(TERM EXPIRES MAY, 1885.)

A. D. PLUMB.
(TERM EXPIRES MAY, 1883.)

WILDER D. STEVENS.
(TERM EXPIRES MAY, 1884.)

F. B. GILBERT.
(TERM EXPIRES MAY, 1884.)

D. E. EMERY.
(TERM EXPIRES MAY, 1885.)

◆

OFFICERS.

A. C. SEKELL, City Surveyor and Sup't Water Works.

FRED A. TWAMLEY, Clerk and Collector.

THOS. J. WILLARD, Assistant Collector.

DEMETRIUS TURNER, 1st Engineer at Pumping Works.

GEORGE E. KIRK, 2d Engineer at Pumping Works.

S. M. BARROWS, TIMOTHY ROSE and GEORGE H. BARROWS, Firemen.

JOHN VAN AMBERG, Foreman of Repairs.

JAMES ENGLISH, Watchman.

REPORT OF THE BOARD.

Board of Public Works,
Grand Rapids, Mich., May 1, 1883.

To the Honorable the Mayor and Common Council of the City of Grand Rapids:

Gentlemen:—In accordance with established usage, the Board of Public Works have the honor to present their report for the year ending April 30, 1883, together with the report of the City Surveyor, the Superintendent of Water Works, the Collector of Water Rates, and of the Engineer in charge of the Pumping Works. The amount and character of the public improvements carried forward under the direction of the Board, a detailed statement of labor performed, and of the receipts and disbursements of the Water Works department are embodied in these several reports, to which your attention is respectfully invited.

For several years the Council have received petitions from residents on numerous streets where there are no water mains, asking for an extension of mains in their several streets, that water may be had for fire protection and for private use. All such petitions have been referred to the Board of Public Works, who have from time to time reported to the Council their inability to lay additional water pipe for want of means to defray the expense. In some exceptional cases the Council have provided funds to lay mains, by which action some important extensions have been made; but in general the Board have been obliged to report no means at their command.

To enable the Board to extend water mains in cases where fire protection and patronage would justify the outlay, they, in July last, recommended to the Council that there be submitted for a vote of the people the question of authorizing the issue of water bonds to the extent of $100,000. It was not proposed to issue such bonds faster than the public necessities should demand. So far as immediate wants might require the sale of such bonds, they could probably be placed at from four to five per cent. This method of providing money was not adopted by the Council, but instead $10,000 were raised by direct tax; of this sum about $9,000 are now available for the extension of mains. The Board have taken action looking to the laying of such additional water pipe as the means at hand will permit. As has been stated in former reports of the Board, any considerable increase in the consumption of water will draw upon the present source of supply beyond their capacity.

For several years the Board have realized the necessity of securing a new source of supply. During a dry season the present water supply is hardly sufficient to meet the demand made upon it. Although a considerable saving has been secured by a new supply pipe, and a more liberal use of meters than formerly, with such a summer as we had in 1879 it would now be necessary to largely restrict the use of water in the months of July, August and September. When citizens who are now supplied with water shall find themselves restricted, and probably in some localities wholly cut off from its use, during the hottest months in the year, they will awaken to the necessity of having new and more abundant sources of supply. It may be the part of wisdom to anticipate such insufficiency of water by taking, at an early day, such action as will make it possible to provide against a water famine that must otherwise overtake the city within a very few years, and possibly before an additional supply can be provided. To this end the Board renew to your honorable body its recommendation of July last, that steps be taken to submit to the people of this city the question of authorizing the issue of water bonds to the amount of $100,000, to be negotiated on the best possible terms that can be obtained at the time of their issue, and that they be issued only as the proceeds shall be required to defray the expense of providing new sources of water supply or extending water mains.

The amount of money that will be required to provide for this city an abundant supply of the best water its locality will permit, is at this time largely a matter of conjecture, as no definite plan has been determined upon. When sufficient means shall be provided to warrant entering upon the work, the question of a new source of supply will become a practical one, one that will be likely to excite some public interest which may in some degree be useful in determining the final plan of operations.

Aside from insufficiency in amount, the rapid growth of the city is each year rendering the present source of supply more objectionable than it has been in preceding years. The present situation is such that the Board feel it to be their duty to the public to strongly urge upon your honorable body the necessity that exists for means to provide new sources of water supply that shall be abundant in volume, and the best obtainable in purity.

The gross receipts from the water works for the year have been $20,347.91; the repairs and operating expenses amount to $12,988.27; making net earnings for the year, $7,359.64. The salaries of the five members of the Board for the past year aggregate $436.50, or an average of $87.20 for each member.

Respectfully submitted,

GEO. W. THAYER,
F. B. GILBERT,
W. D. STEVENS,
A. D. PLUMB,
D. E. EMERY,
Board of Public Works.

SUPERINTENDENT'S REPORT.

Office of Superintendent of Water Works,
Grand Rapids, Mich., May 1, 1883.

To the Honorable Board of Public Works:

Gentlemen:—I have the honor to submit herewith the annual report relative to the Grand Rapids Water Works for the year ending April 30, 1883:

RESERVOIR.

The reservoir is in good condition. No expenditures during the year have been made, except a small sum for cutting grass on the slopes of the embankment. The baren sand banks in Mason street on the line of the force main are still in an unsatisfactory condition, no definite plan for improvement having yet been adopted. During the coming month the experiment of planting slips of Lombardy poplars will be made, and should it prove satisfactory, a cheap and ready method of protecting these bluffs from the action of storms and rendering them less unsightly in appearance will be at hand.

SETTLING BASIN AND SUPPLY CREEKS.

Work at the settling basin has been limited during the year to keeping the grounds in order and making some slight repairs, the total expense incurred being $52.80.

The supply creeks have been daily patrolled by a watchman, as in the previous year. The cost of this service was $203.00.

The continued increase in the number of water consumers suggests the importance of attention to the question of an additional supply of water, which still remains unsettled. So long as the amount of water flowing into the supply creeks exceeds the daily consumption, there will exist no apprehension on the part of the general public; the moment, however, the demand exceeds the supply and restrictive measures to prevent waste of water are put in operation, the question is likely to be forced prominently into public notice, possibly to the prejudice of well-matured designs for future action.

The saving of water resulting from the general introduction of meters into business blocks and manufactories, has undoubtedly been the means of tiding over the periods of greatest use during the past year, but about all that can be accomplished by meters has been done. The policy of a general introduction of meters into residence property may be doubted, and hence nothing further can be looked for in this direction. The approximate daily consumption for each service for the year ending April 30, 1881, was 1,600 gallons; for the next year the average was 1,280, while for the year past it was 1,271 gallons.

HYDRANTS AND VALVES.

The hydrants and valves are in good condition. No new hydrants have been set during the year.

During the winter a load of logs on runners slid against a post hydrant on the corner of East Bridge and Ottawa streets, breaking the stand-pipe and frost case.

Two new valves were set on new lines of pipe, and one valve was set on the Lyon street line at the west line of Canal street.

The original hydrant and valve boxes, which are of wood, give increasing trouble. The valve boxes are replaced as fast as they fail with the Bingham and Morgan cast-iron boxes, of which eighteen have been set during the year.

The hydrant boxes are to be replaced with brick having a cast-iron cover of a new design, which, it is believed, will obviate largely the objections existing against the covers now in use.

SERVICE CONNECTIONS.

During the year permits have been issued for 95 service connections, or 15 less than were issued the previous year. There were also connected with the mains six private lines.

The total number of connections at present made with the works is 1,171, of which 114 are cut-off and 1,057 open.

METERS.

Fifty meters have been added during the year, the total number now owned by the city being 355, of which there are set and in operation 328 of the following manufacture:

Ball & Fitts, Rotary	199
Worthington	7
Crown	51
Ball & Fitts, Piston	71
Total	328

There are in the repair shop as follows:

Ball & Fitts, Rotary	19
Worthington	1
Crown	0
Ball & Fitts, Piston	7
Total	27

There is in use one Undine, which is running on trial.

The effect of the meters in restricting waste continues, although the average consumption per service is still very large.

MAINS.

No important extentions to the mains have been made during the year. A four-inch line was laid in Madison avenue, from the Cherry street line north a distance of 400 feet, at the expense of property owners interested under an understanding with the Board that the cost was to be refunded to them when funds for water pipe extensions were at the disposal of the Board. The amount expended was $340.79, and the same was returned to the parties advancing the same by action of the Board of date March 31, 1883.

A four-inch line was also laid in Summer street, from the south end of the pipe previously laid south to connect with the line in West Fulton street. The cost of this work was $114.90, and the expense was borne by the Phœnix Furniture Company.

The twelve-inch line crossing the river at Fulton street has been completed, adding greatly to the efficiency of the system on the West Side, and increasing the pressure for fire protection. The work of laying this main from South Front street on the West Side to Waterloo street on the East Side was done by the day, under the immediate direction of the Superintendent of Water Works, at a total expense for labor and material, exclusive of the iron pipe, of $2,736.64, of which $555.14 was expended during the past year and $2,181.50 the year previous. Prior to commencing the work of laying this pipe the Board received proposals for the same, the lowest bid received being $8,695.00, or $5,958.36 more than the actual amount which has been expended.

LEAKS ON DISTRIBUTION MAINS.

The following table shows the number, cause and location of the various leaks on the mains during the year:

NAME OF STREET.	KIND OF PIPE.	Size. Inch.	DATE.	CAUSE.
Ottawa	Iron	12	May 1	Joint.
Coldbrook	"	20	" 2	"
Coldbrook	"	20	" 19	"
Scribner	Wyckoff	8	June 15	"
Scribner	"	8	" 22	"
South Division	"	12	July 3	"
Scribner	"	8	" 5	"
Bronson	Pump Log	6	" 6	Split.
North Canal	Wyckoff	8	" 6	Joint.
North Division	"	4	" 13	"
Bronson	Pump Log	6	" 19	"
Ottawa	Wyckoff	3	" 20	"
North Canal	"	8	" 22	"
South Front	"	6	August 8	"
West Bridge	"	12	" 9	"
West Bridge	"	12	" 17	"
Fountain	Pump Log	6	" 21	Split.
North Canal	Wyckoff	8	" 29	Joint
South Division	"	12	September 1	"
Prescott	Iron	8	" 2	"
Scribner	Wyckoff	8	" 4	"
Summer	Iron	4	" 7	"
Scribner	Wyckoff	8	" 12	"
Waterloo	"	8	" 16	"
Fountain	Pump Log	6	" 28	Split.
South Division	Iron	8	October 20	Joint.
Scribner	Wyckoff	8	" 26	"
Bronson	Pump Log	6	" 30	Split.
Coldbrook	Iron	20	November 7	Joint.
Buchanan	"	6	" 8	"
Broadway	Wyckoff	12	" 29	"
Prescott	Iron	8	January 18	"
West Fulton	"	12	March 20	"
Broadway	Wyckoff	12	April 11	"
Scribner	"	8	" 12	"
Louis	"	4	May 8	"
Bronson	Pump Log	6	" 9	"

The total number was 37 against 55 the previous year, and 43 the year before that.

The total length of water mains now laid is 24.83 miles; number of fire hydrants, 260; number of valves, 158.

Respectfully submitted,

A. C. SEKELL,

Superintendent.

COLLECTOR'S REPORT.

OFFICE OF BOARD OF PUBLIC WORKS,
Grand Rapids, May 1, 1883.

To the Honorable Board of Public Works:

GENTLEMEN:—I respectfully present the following report for the year ending April 30, 1883:

The number of services on the 1st of May, 1882, for which permits were issued were	1,022
Taps granted without permits	25
Private mains connected with works	23
Total	1,070
Number of services put in the past year for which permits were issued	95
Private mains connected with works	6
Total number of connections on May 1, 1883	1,171
Number of services now cut off	114
Number of services now open	1,057

The receipts at this office for the year have been as follows:

From water rates	$19,758 16
From water permits	589 75
Total income from water works	$20,347 91

There has also been received from labor and sale of material	564 66
From sewer permits	120 00
From contractors' forfeits on bids	20 00
Total receipts for the year	$21,052 57
Cash on hand May 1, 1882	383 61
	$21,436 18

Deposits have been made with the City Treasurer during the year as follows:

To the credit of water works income fund	$20,354 14
To the credit of water works fund	564 66
To the credit of general fund	20 00
To the credit of 1st district sewer fund	85 50
To the credit of 2d district sewer fund	34 50
Total deposits during the year	$21,058 80
Cash on hand to balance	377 38
	$21,436 18

Receipts from May 1, 1874, the commencement of collections, to May 1, 1882:

From water rates	$ 94,705 15
From water permits	5,591 23
From sewer permits	529 50
From various sources (as per past reports)	1,366 79
Total	$102,192 67
Receipts for the past year	21,052 57
Total receipts to date	$123,245 24

Deposits made from May 1, 1874, to May 1, 1882:

To the credit of water works income fund	$100,780 28
To the credit of water works fund	361 28
To the credit of 1st district sewer fund	261 00
To the credit of 2d district sewer fund	79 50
To the credit of contingent fund	40 00
To the credit of Jackson street grading fund	277 00
To the credit of general fund	10 00
Total	$101,809 06
Deposits made the past year	21,058 80
Cash on hand to balance	377 38
Total	$123,245 24

STATEMENT OF EXPENDITURES.

May 1, 1882, to May 1, 1883.

CONSTRUCTION OF WATER WORKS.

1.—Pipe System.

Main under river	$ 598 34
Miscellaneous	1,342 36
	$ 1,940 70

2.—Meters.

New meters and setting	$ 1,249 91
Total paid on construction	$ 3,190 61
Paid previous to May 1, 1882	443,319 21
Cost of works to date	$446,509 82

MAINTENANCE AND OPERATION OF WATER WORKS.

1—PUMPING.

Salary Engineer	$	1,200 00
" Assistant Engineer		900 00
" First fireman		600 00
" Second fireman		600 00
" Third fireman		547 50
Fuel		3,304 92
Repairs to Pumping machinery		21 50
" Boilers		83 90
" Boiler arches		192 33
" Engine house		40 95
Supplies (oil, packing, etc)		403 39
	$	7,894 49

2.—OFFICE AND COLLECTING.

Salary, Collector	$	750 00
" Assistant Collector		420 00
Stamps and stationery		13 50
	$	1,183 50

3.—SUPERINTENDENCE AND REPAIRS.

Salary Superintendent	$	300 00
" Foreman of repairs		720 00
	$	1,020 00

1.—IRON PIPE.

Labor	$	67 00

2.—WYCKOFF PIPE.

Labor	$342 29	
Material	216 01	
		558 30

Amount forward		$1,645 30

3.— PUMP LOGS.

Labor	$ 71 52	
Material	24 08	
		95 60

4.—SUPPLY PIPE.

Labor	$234 25	
Material	10 26	
		244 51

5.—VALVES.

Labor	$226 61	
Material	10 95	
		237 56

6.—HYDRANTS.

Labor	$200 86	
Material	160 38	
		361 24

7.—METERS.

Labor	$280 81	
Material	85 28	
		366 09

8.—RESERVOIR.

Labor		43 45

9.—SETTLING BASIN.

Labor		52 80

10.—SUPPLY CREEKS.

Salary watchman		203 00

Amount forward		$3,249 55

11.—SERVICE CONNECTIONS.

Labor	$ 87 98	
Material	476 07	
		564 05

12.—MISCELLANEOUS.

Tools	$ 82 93	
Blowing off	13 75	
		96 68
		$ 3,910 28

RECAPITULATION.

Pumping	$ 7,894 49
Office and collecting	1,183 50
Superintendence and repairs	3,910 28
Total paid for maintenance and operation	$ 12,988 27
Paid previous to May 1, 1882	75,081 06
Total paid to date	$ 88,069 33
Income for the year	20,347 91
Cost of maintenance and operation	12,988 27
Excess of receipts over expenditures	$ 7,359 64

Respectfully submitted,

FRED A. TWAMLEY,

Collector.

ENGINEER'S REPORT.

Grand Rapids, May 1, 1883.

To the Honorable Board of Public Works:

Gentlemen:—I have the honor to submit herewith my annual report of the work done by the pumping engines for the year ending April 30, 1883.

The machinery has been running on 364 days, or a total of 4,058 hours. The engines and boilers are in good repair, and working in a satisfactory manner.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, and amount of wood burned. The estimated quantity of water pumped per revolution is 100 gallons:

MONTH.	Days Pumpd	Time Run. H. M.	No. of Revolutions.	Gal's Water Pumped.	Cords of wood Used.	Cost of Wood Used.
May	31	310—20	353,425	35,342,500	154	$254 10
June	30	352—25	412,072	41,207,200	155	255 75
July	31	402—40	459,387	45,938,700	166	273 90
August	31	309—00	367,155	36,715,500	155	255 75
September	30	359—20	402,110	40,211,000	162	267 30
October	31	291—05	338,111	33,811,100	135	222 75
November	30	264—50	311,965	31,196,500	129	212 85
December	31	328—40	383,979	38,397,900	144	237 60
January	31	381—10	452,833	45,283,300	169	278 85
February	28	359—55	405,100	40,510,000	171	282 15
March	31	372—55	428,356	42,835,600	189	311 85
April	30	322—45	374,433	37,443,300	152	250 65
Total	365	4,058—5	4,688,926	468,892,600	1,881	$3103 65

Total cost of raising one million gallons into reservoir, $16.71 9-10.

Cost of pumping one million gallons 100 feet high...	$11 14
Cost of fuel to raise one million gallons into reservoir	6 61
Cost of fuel to raise one million gallons 100 feet.....	4 40

The running expenses for the year have been:

Engineer salaries..............................	$2,100 00
Firemen salaries......	1,747 50
Fuel..	3,673 04
Total..................................	$7,520 54

	Repairs	Supplies.	
Leonard & Ellis.........	......	$118 00	118 00
S. G. Preston...........	......	16 50	16 50
Fred Maybury..........	......	35 00	35 00
John Olson.............	$141 63	......	141 63
G. Crump & Son...	38 25	......	38 25
Bass Foundry and Machine Works	......	23 25	23 25
E. P. Thayer...........	......	49 13	49 13
L. D. Putnam	......	40 21	40 21
Shriver, Weatherly & Co..	29 56	......	29 56
E. G. Studley...........	......	85 22	85 22
Foster, Stevens & Co....	......	4 31	4 31
Michigan Iron Works....	69 31	......	69 31
A. Leitelt...............	217 64	20 52	238 16
Total...............	$496 39	$392 14	$ 888 53
New work, fixing boiler to burn coal.........			552 35
Total..................................			$8,961 42

Respectfully submitted,

DEMETRIUS TURNER,

Engineer Pumping Machinery.

CITY SURVEYOR'S REPORT.

City Surveyor's Office,
Grand Rapids, Mich., May 1, 1883.

To the Honorable Mayor and Common Council:

Gentlemen:—I have the honor to submit herewith the annual report of improvements conducted by the Board of Public Works during the past year:

The following tables show the street improvements which have been completed during the year, the character and cost of each improvement, and also the street improvements now under contract.

STREET IMPROVEMENTS COMPLETED DURING THE YEAR ENDING APRIL 30, 1883.

NAME OF STREET.	FROM	TO	KIND OF IMPROVEMENT.	Length in Feet.	Contract Price.	Inciden-tals.	Total Cost.	Per Foot.	CONTRACTORS.
S. Ionia	E. Fulton	Cherry	Graded & paved with cobble stone	1,226					
	Cherry	Wealthy Ave.	Road bed paved with cobble stone	1,244	$ 6,900 00	$377 74	$ 7,277 74	$2 95	C. Utes.
Jackson	Marion	W. City Limits	Graded and graveled	595	534 00	......	......	......	A. Wiseman.
Henry	Cherry	Fifth Ave.	Graded, graveled & gutters paved.	3,971	10,113 00	250 89	10,363 89	2 61	A. & W. Wiseman
N. Ionia	Lyon	E. Bridge	" " " "	1,074	2,246 00	114 18	2,360 18	1 27	B. Livingston.
Coit Ave.	Fairbanks	Bradford	" " " "	750	1,393 00	80 12	1,473 12	1 96	C. Prange.
Maple Ave.	Third	Fourth	Graded and graveled	330	297 00	43 28	340 28	1 03	A. Wiseman.
Campau	Lyon	Pearl	Repaired	......	990 00	65 52	1,055 52	......	C. Prange.

STREET IMPROVEMENTS NOT COMPLETED DURING THE YEAR ENDING APRIL 30, 1883.

NAME OF STREET.	FROM	TO	KIND OF IMPROVEMENT.	Length in Feet	Contract Price.	Estimated Incidentals.	Total Amount.	CONTRACTORS.
E. Fulton	Spring	Waterloo	Graded, paved with wood & stone	1,100	$5,790 00	$235 00	$ 6,025 00	Joel Collins.
Fourth Ave.	S. Division	Grandville	Graded, graveled & gutters paved	2,656	5,200 00	300 00	5,500 00	" "
N. Waterloo	Monroe	E. Fulton	Paved with wood	1,070	2,025 00	100 00	2,125 00	" "
Alley bet Clinton and Livingston	E. Bridge	Hastings	Graded	500	350 00	30 00	380 00	" "
Ottawa	Monroe	E. Fulton	Graded, paved with wood & stone	778	2,950 00	150 00	3,100 00	J. C. Murray.
Pearl	Ottawa	N. Ionia	" " " " "	264	1,525 00	55 00	1,580 00	" "
Davis	Fourth	W. Leonard	Graded and graveled	4,189	5,972 00	228 00	6,200 00	C. Prange.
Pleasant	S. Division	S. Lafayette	Graded, graveled & gutters paved	1,497	3,000 00	150 00	3,150 00	B. Livingston.
Brainard	E. Bridge	D. & M. R. R.	" " " "	1,050	2,600 00	75 00	2,675 00	P. J. Britton.
Fountain	Prospect	E. City Limits.	Paved gutters, repaired roadbed.	2,835	2,600 00	400 00	3 000 00	Joel Collins.
Lagrave	E Fulton	Maple	" " " "	1,732	1,950 00	150 00	2,100 00	I. B. Mathewson.
Alley bet. N. Ionia and Ottawa	Bronson	E. Bridge	Graded and paved with stone.	524	773 00	37 00	810 00	C. Prange.
Sinclair	E. Bridge	Hastings	Graded, graveled & gutters paved	631	1,550 00	60 00	1,610 00	P. J. Britton.
Winter	W. Bridge.	Shawmut	Graded and graveled	1,582	3,095 00	115 00	3,210 00	C. Utes.
Huron	Canal	Lock	Graded and paved with stone.	168	445 00	30 00	475 00	A. Wiseman.
Hastings	Clinton	College	Graded, graveled & gutters paved	2,645	6,966 00	234 00	7,200 00	A. Wiseman.
Bank	E. Bridge	Squires' Alley.	Graded and graveled	278	421 39	28 61	450 00	I. B. Mathewson.

SEWERS.

The work of constructing new outlets for the East Fulton street sewer, and the East Bridge, Lyon and Monroe streets sewers, mention of which was made in the report of last year, has not been completed.

During the year the East Fulton street sewer was extended from the junction of East Fulton and Waterloo streets to the bank of the river, ready for connection with the wrought iron pipe which is to extend to the channel near the middle of the river. The contract for the construction of the iron pipe for both outlets was awarded to A. Leitelt August 19, 1882, but owing to delays in procuring the iron the season for laying passed before any of the pipe could be manufactured. There has been expended for this work $2,698.81 of the original appropriation of $9,000.

There remains to construct the brick work for the outlet of the Monroe and Pearl streets sewers, and the East Bridge and Lyon streets sewers, and to lay the iron pipe outlets to the middle of the river.

The total length of the sewerage system is 24.362 miles, of which there are:

Brick sewers	10.529	miles.
Glazed pipe sewers	11.500	"
Cement pipe sewers	.480	"
Wood sewers	1.853	"
Total	24.362	miles.

The following tables show the sewers completed during the year, with their location and cost, and also the sewers now under contract.

SEWERS COMPLETED DURING THE YEAR ENDING APRIL 30, 1883.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man-holes.	Catch Basins.	Length in Feet.	Contract Price.	Inciden-tals	Total Cost.	CONTRACTORS.
Seventh	From Alpine Ave. to sewer in Davis St.	20x30 in. brick. 12 in. glazed pipe.	2	4	650 38	$1,212 00	...	...	Mathewson & Leonard.
N. Front	From Sixth St. to sewer in Fourth St., and from 40 ft. north of Sixth St. to sewer in Eighth St.	12 " " " 9 " " "	2 1	5 1	780 475	1,302 70	..	....	J. Collins.
Madison Ave	From 75 ft. N. of State St. to sewer in Washington	6 " " "	1	....	532	364 00	...		J. C. Murray.
Alley bet. Ottawa and Ionia from Bronson to E. Bridge	From 50 ft. S. of E. Bridge to Bronson St. sewer.	9 " " "	1	....	520	560 00	...	....	J. Collins.
Alley bet. Ottawa and Ionia from Bronson to Lyon	From 75 ft. N. of Lyon St. to sewer in Bronson St.	9 " " "	1	...	455	470 00	....	...	L. Schneider,
Springfield Ave.	From Fremont St. to Stocking St. in Stocking St. to sewer in Fifth St	12 " " " 9 " " "	1	. .	136 600	591 00	...	..	J. C. Murray.
S. Lafayette	From 276 ft. S. of Cherry St. to Cherry St. sewer.	9 " " "	1	..	324	248 00	....	..	L. Schneider.
N. Division	From 50 ft. S. of E. Bridge St. in E. gutter to sewer in Bronson St	9 " " "	1		531	290 00	....	...	J. Collins.
Jefferson	From 25 ft. N. of California St to Sibley St. sewer	9 " " "	2	2	622	530 00	....	....	C. Utes.
Quimby and Perry	From W. line of Colt Ave. in S. gutter to Perry St. Thence S. in W. gutter to Madison St.	24x24 in. Wooden box.			749	750 00	...	....	J. C. Murray.
Straight	From 25 ft. S. of W. Bridge St. to sewer in Sibley	12 in. glazed pipe. 9 " "	4	6	978 306	1,393 00	....	..	L. Schneider.
Eighth	From N. Front St. to sewer in Broadway St	16x24 brick.	3	4	885	1,625 00	...	...	L. Schneider.
Alley bet. Mt. Vernon and Summer from Shawmut to W Fulton	From 75 ft S of Shawmut Ave to sewer in Fulton St	9 in. glazed pipe.	2	.	873	594 00	...	....	L. Schneider.

SEWERS UNDER CONTRACT AND NOT COMPLETED.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man-holes.	Catch Basins.	Length in Feet.	Contract Price.	Estimated Incidentals.	Total Amount.	CONTRACTORS.
Winter St sewer extension in Broadway	In W. Bridge St. from Winter St. sewer to Broadway St. N. in Broadway St. to North St ...	12 in. glazed pipe 20x30 in. brick. 35x45 " " 41x53 " " 56x72 " "	 18	 40	1410 1222 1311 1303 2804	$25,547 00	$1,203 00	$26,750 08	McBrian & Farr.
Seventh and Davis .	In Seventh St. from Broadway St. sewer W. to Davis St., N. in Davis St. to W. Leonard St .	30x45 " " 40x53 " " 45x52 " "	.. 7	 8 ..	1330 1310 1550	15,775 00	725 00	16,500 00	Ç. Prange.
South Division St. and Wealthy Ave . ..	In S Division St. from S. line Wenham Ave. N. to Wealthy Ave., E in Wealthy Ave. to Cass St.	26x39 " "	7	10	1838	7,200 00	800 00	8,000 00	J. Collins.
N. Front.	From 25 ft. N. of Second St. to sewer in Fourth St.	12 in. glazed pipe 9 " " "	2 ...	2 ..	414 311	598 00	62 00	660 00	J. Collins.
Grandville Ave... . .	From Summit St. to sewer in Prescott St	12 " " "	4	4	1391	1,590 00	110 00	1,700 00	C. Utes.

CRESCENT PARK.

A contract for constructing a stone stairway was awarded April 28 to Alexander Matheson for $1,606.50.

IRON BRIDGES.

A contract for the construction of an iron bridge across the river at Bridge street was awarded February 14, 1883, to the Morse Bridge Company of Youngstown, Ohio, for the sum of $21,800.

This bridge will have an extreme length of 664 feet, a clear width of roadway of 22 feet, and sidewalks each 8 feet wide. The bridge will be proportioned to carry a rolling load of 2,500 pounds per linear foot with maximum strains in accordance with standard practice.

The short span which connects the above mentioned work with the east bank of the river, mention of which was made in the report of last year, has been completed at a cost of $1,642.24. This span is 39 feet long, and was built by the Wrought Iron Bridge Company of Canton, Ohio.

The following is the cost of the several improvements which have been brought to completion during the year:

Street improvements	$22,870 73
Sewerage	9,929 70
Bridge span, abutment and approach	5,460 50
Total	$38,260 93

Respectfully submitted,

A. C. SEKELL,

City Surveyor.

INVENTORIES MAY 1, 1883.

Pipe, etc., at pumping station:

16 pieces 4 inch, 12 ft. long
20 " 6 " 12 "
5 ' 8 " 12 "
6 " 10 " 12 "
31 " 12 " 12 "
1 " 14 " 12 "
5 " 16 " 12 "
7 " 20 " 12 "
1 " 20 " 2½ "
1 " 20 " 6½ "
2 " 20 " 10 "
1 " 12 " 8 "
4 " 12 " 6 "
5 " 12 " 11 "
4 " 12 " 4 "
3 " 12 " 3 "
2 " 12 " 2 "
1 " 10 " 2½ "
5 " 8 " 6 "
1 " 8 " 4 "
5 " 6 " 9 "
6 " 6 " 3 "
5 " 6 " 2 "
2 " 6 " 1 "
2 New hydrants.
1 4-inch plug.
6 4-inch sleeves.
6 6-inch sleeves.
13 8-inch "
1 10-inch "
2 14-inch "
2 16-inch "
2 20-inch "
1 reducer hub ends 16 to 12.
1 Lot of 16-inch Wyckoff pipe, about 400 feet.
1 Lot of old Wyckoff pipe, small size.
1 20-inch flange valve.
1 Three way, 12x12x6.
1 " " 12x12x4.
1 " " 10x10x6.
1 " " 4x 4x4.
10 Valve-box covers (complete).
2 Valve-box covers (incomplete).
4 Ludlow hydrants (old).
1 4-inch hydrant base.
1 Hydrant base plate.
1 12-inch plug.
10 6-in. pump log thimbles.
1 Lot old iron.
1 Two-wheel derrick.

Stock and tools at repair shop:

4 New valves for Mathew hydrants.
2 Iron stems for Lowry hydrants.
7 8-inch valve stems with head.
3 10-inch valve stems with head.

3 Stand-pipes for Lowry hydrants.
10 Brass stems for Lowry hydrants.
10 Rubber valves for Lowry hydrants.
3 Castings for Lowry hydrant valves.
7 Calking irons.
2 Cut-off saws.
1 Rip saw.
1 Cross-cut saw.
1 Compass saw.
2 Pipe cutters.
1 Cutter stock and 4 dies.
5 Taps.
3 Crowbars.
1 Claw hammer.
2 Sledge hammers.
12 Files.
2 Ice picks.
5 Castings for Lowry hydrants.
1 Brass value for Lowry hydrant.
2 Lbs. springs for Lowry hydrant drips.
2 Glands.
1 4-inch valve stem with head.
4 4-inch valve stems with head.
5 6-inch valve stems with head.
10 1-inch corporation stops for iron pipes.

NEW METERS.

3 Ball & Fitts, Rotary.
1 12-inch valve stem with head.
1 14-inch valve stem with head.
1 16-inch valve stem with head.
6 Heads for valve stems.
1 Valve box cover.
60 Feet of 1½-inch rope.
40 " 1 " "
13 Thimbles for Wyckoff pipe.
4 Bolts for hydrant extensions.
1 Bundle shingles.
20 Lbs. solder.
50 Lbs. lead.
10 Lbs. nails.
1 Bushel charcoal.
5 Gallons coal tar varnish.
47 Iron bands with bolts.
24 ½-inch corporation stops for wood pipe.
41 ⅝-inch corporation stops for wood pipe.
43 ¾-inch corporation stops for wood pipe.
57 ½-inch corporation stops for iron pipe.
34 ⅝-inch corporation stops for iron pipe.
35 ¾-inch corporation stops for iron pipe.
2 Braces.
6 Tapping drills.
19 Tapping Augers.
1 Extension bit.
1 Drilling ratchet.

OLD METRES.

7 Ball & Fitts, Piston.
16 “ “ Rotary.
1 Worthington.
2 Oil cans.
6 Lanterns.
1 Pair dividers.
25 Shovels.
8 Picks.
1 Large clamp.
2 Small drill clamps.
1 Bench vice.
6 Pails.
2 Large valve wrenches.
1 Lowry hydrant wrench.
2 Post hydrant wrenches.
4 Cut-off street keys.
2 Hydrant heads.
2 Pair rubber boots.
2 Screw drivers.
1 Hatchet.
1 Jack plane.
3 Pumps.
1 Light derrick.
3 Pulleys.
2 Small brushes.
1 Maul.
2 Wrenches.
1 Scraper.
2 Saw benches.
34 Stop-cock boxes.
2 Pipe wrenches.
1 Brest drill.
1 Large monkey wrench.
2 Small “ “
2 S. wrenches.
1 Steamer.
6 Wheelbarrows.
1 Saw set.
3 Cold chisels.
1 Wood chisel.
3 Punches.
2 Calking hammers.
1 Machinist's hammer.
1 Testing pump.
1 Fire pot.
2 Baskets.
36 Feet tape line.
1 Snow shovel.
40 Screws for lowering pipe.
1 Pair hose couplings.
1 10-inch Eddy valve.
2 6-inch valves.
9 Iron valve boxes.
100 Lbs. sheet lead.
2 Gasket irons.
1 Lot old iron.
1 “ “ rubber.
1 “ “ hose.
1 “ “ iron pipe fittings.
Lot old bolts and nuts.
1 “ rubber packing.
1 “ hoop iron.
1 “ gasket yarn.
1 Stove and pipe.

Stock and tools at Pump House:

148 Cords slabs.
25 Gallons Valvoline oil.
30 “ Machine oil.
3 Spirt oil cans.
1 Match safe.
10 Drip oil pans.

1½ Gallons Castor oil.
300 Lbs. boiler compound.
½ Set pump valves for new engine.
50 Feet of 1½-inch hose and nozzle.
24 Feet of steam hose and couplings.
10 Brooms.
3 Mops.
2 Lanterns.
1 Boiler scraper.
1 4-inch steam flue blower.
4 Long boiler scrapers.
2 Long valve wrenches.
4 Common wrenches.
1 Long socket wrench.
1 Short " "
12 Spanners.
2 Large monkey wrenches.
4 Small " "
2 Door mats.
2 Scoop shovels.
1 Long-handle shovel.
1 Common hoe.
1 Hand saw.
1 Garden rake.
1 2½-inch hose nozzle.
1 ¼-inch " "
1 Bit stock.
22 Feet of 2½-inch gas pipe.
8 " ½-inch " "
16 " 1½-inch " "
14 " 1¾-inch " "
13 " 2¾-inch " "
1 Five gallon oil can.
2 Two gallon " "
1 One gallon " "
1 Brick trowel.
4 Yards canvas.
1 Vise.
2 Water pails.
1 Step ladder.
2 Long "
1 Short "
6 Chairs.
1 Dust pan.
3 Hand lamps.
5 Wall "
1 Brass oil pan.
1 1¼-inch auger.
4 Small bits.
1 Packing hook.
6 Cold chisels.
3 Files.
1 Steam gauge.
4 Glass tubes for air chamber.
1 Glass tube for boiler.
3 2½-inch old globe valves.
2 2-inch " " "
2 1½-inch " " "
3 1-inch " " "
2 ¾-inch " " "
1 1-inch check valve.
1 1¼-inch " "
2 ¾-inch " "
1 2½-inch brass coupling.
1 ¾-inch iron coupling.
2 2-inch " "
1 3-inch " "
2 1-inch plugs.
7 2½-inch flanges.
3 2½-inch tees.
1 12-feet eye bolt.
1 Lot of bolts.

2 One quart oil can
2 One pint " "
1 Stock and die.
50 Lbs. waste.

Furniture, etc., in office:

1 Safe.
1 Counter.
1 Stove.
1 Desk.
1 Telephone.
1 Standing desk.
3 Tables.
16 Chairs.
1 Letter press and stand.
1 Stool.
1 Map of water mains.
1 Portfolio water maps.
2 Cases of stationery.
1 Case reports.
4 Cuspidores.
2 Waste baskets.
1 Water crock.

ANNUAL REPORT

OF THE

BOARD OF PUBLIC WORKS

AND

CITY SURVEYOR,

FOR THE FISCAL YEAR ENDING APRIL 30, 1884.

GRAND RAPIDS, MICH.:
ISAAC S. DYGERT, AGENT, PRINTER.
1884

REPORT

OF THE

BOARD OF PUBLIC WORKS

TO THE

Common Council of the City of Grand Rapids,

Transmitting the Reports of the

COLLECTOR & ENGINEER

OF THE WATER WORKS,

FOR THE FISCAL YEAR ENDING APRIL 30, 1884.

ALSO THE

ANNUAL REPORT OF THE CITY SURVEYOR.

GRAND RAPIDS, MICH.:
ISAAC S. DYGERT, AGENT, PRINTER.
1884.

BOARD OF PUBLIC WORKS.

GEORGE W. THAYER, President.
(Term Expires May, 1885.)

WILDER D. STEVENS.
(Term Expires May, 1884.)

F. B. GILBERT.
(Term Expires May, 1884.)

D. E. EMERY.
(Term Expires May, 1885.)

A. D. PLUMB.
(Term Expires May, 1886.)

OFFICERS:

H. A. COLLAR, City Surveyor.
FRED A. TWAMLEY, Clerk and Collector.
THOS. J. WILLARD, Assistant Collector.
DEMETRIUS TURNER, 1st Engineer at Pumping Works.
GEORGE E. KIRK, 2d Engineer at Pumping Works.
S. M. BARROWS, GEORGE H. BARROWS and MYRON GATES, Firemen.
JOHN VAN AMBERG, Foreman of Repairs.
JOHN DOYLE, Watchman.

REPORT OF THE BOARD.

To the Honorable the Mayor and Common Council of the City of Grand Rapids:

GENTLEMEN:—The Board of Public Works have the honor to submit their report for the fiscal year ending April 30, 1884, together with the report of the City Surveyor, the Collector of Water Rates and of the Engineer in charge of the Pumping Works. Your attention is invited to these several reports. That of the City Surveyor will show the extent and character of the street improvements made, and of all sewers constructed during the past year, and of other important public work carried on under the direction of the Board.

The report of the Collector of Water Rates presents a statement of all receipts and disbursements in connection with the Water Works. That of the Engineer of the Pumping House shows the amount of water supplied to the city, the amount, kind and cost of the fuel consumed, and the expense of the Pumping Works for the year.

The gross receipts from the Water Works for the year have been $24,136 59 against $20,347.91 for the previous year. The repairs and operating expenses for the present year have been $16,873.64 against $12,988.27 for last year. Net earnings for the year $7,762.75 against $7,359.64 for preceding year. The considerable increase in repairs and operating expenses for the past year consists largely in a reconstruction of the fire arches under the boilers, together with repairs and reconstruction about outlet of one of the supply creeks.

Since the report last submitted new stone piers for an iron bridge across the river at Bridge Street have been built, and it is expected that within a few weeks the new bridge and its approaches will be fully completed, and opened to travel. The total cost of the abutments, piers and bridge, including the new iron span erected in 1883, will be about $35,000.

Some preliminary work has been done looking to the building, during the present season, of abutments and piers for a new iron bridge to span the river at Fulton Street.

Within the past year a new engine house has been constructed in the Eighth Ward, for the use of the Fire Department, at a cost of $6,668.72.

The stone stairway in Crescent Park has been completed since the date of the last annual report. All that was looked for in this improvement has been attained, it being attractive in appearance and serviceable in its use.

The question of a better and more abundant water supply for the city, although, as heretofore undetermined, may be reported as advancing somewhat towards a solution. A small amount of money for experimental purposes having been included by the Council in the last annual budget, the Board have taken initiatory action looking to the making of some tests for water the present season, that it is hoped may secure satisfactory results.

The recent vote of electors authorizing the issue of the Bonds of the city to the amount of $150,000 for the purchase of additional real estate and the erection of a City Hall, will bring to the Board new cares and responsibilities, but they will be cheerfully undertaken, hoping finally to be able to have our city represented by a building that will meet the expectations of our citizens, so far as it may be possible to do so with the means provided for the purpose. The preliminary work, and the careful consideration necessary, before the erection of the building can commence, together with the numerous other demands made upon the time and attention of the Board, may incline some of our citizens to think them dilatory in their action, but in the absence of specific information, inactivity on the part of the Board should not be assumed. They must be permitted to take such time and methods as it shall appear to them the importance of the work in charge may demand.

The total expenditures for the past year, for all classes of work carried on under the direction of the Board will exceed $128,000, being a large increase over most of the preceding years.

Respectfully submitted,

GEO. W. THAYER,
WILDER D. STEVENS,
F. B. GILBERT,
D. E. EMERY,
A. D. PLUMB,
Board of Public Works.

COLLECTOR'S REPORT.

OFFICE OF BOARD OF PUBLIC WORKS,
Grand Rapids, May 1, 1884.

To the Honorable Board of Public Works:

GENTLEMEN:—I respectfully present the following report for the year ending April 30, 1884:

The number of services on the 1st of May, 1883, for which permits were issued were	1,117
Taps granted without permits	25
Private mains connected with works	29
Total	1,171

Number of services put in the past year for which permits were issued	130
Private mains connected with works	6
Total number of connections on May 1, 1884	1,307
Number of services now cut off	131
Number of services now open	1,176

The receipts at this office for the year have been as follows:

From water rates, fines, etc	$23,837.34
From water permits	799.25
Total income from water works	24,636.59

There has also been received from labor and sale of material	267 46
From sewer permits	243 00
From contractors' forfeits on bids and fines	140 00
Total receipts for the year	$25,287 05
Cash on hand May 1, 1883	377 38
	$25,664 43

Deposits have been made with the City Treasurer during the year as follows:

To the credit of water works income fund	24,512 70
To the credit of water works fund	267 46
To the credit of general fund	40 00
To the credit of 1st district sewer fund	180 00
To the credit of 2d district sewer fund	63 00
To the credit of South Division street sewer fund	100 00
Total deposits during the year	$25,163 16
Cash on hand to balance	501 27
	$25,664 43

Receipts from May 1, 1874, the commencement of collections, to May 1, 1883:

From water rates	$114,463 31
From water permits	6,180 98
From sewer permits	649 50
From various sources (as per past reports)	1,951 45
Total	$123,245 24
Receipts for the past year	25,287 05
Total receipts to date	$148,532 29

Deposits made from May 1, 1874, to May 1, 1883:

To the credit of water works income fund	$121,134	42
To the credit of water works fund	925	94
To the credit of 1st district sewer fund	346	50
To the credit of 2d district sewer fund	114	00
To the credit of various funds (as per past reports)	347	00
Total	$122,867	86
Deposits made the past year	25,168	16
Cash on hand to balance	501	27
Total	$148,532	29

STATEMENT OF EXPENDITURES.

May 1, 1883, to May 1, 1884.

CONSTRUCTION OF WATER WORKS.

1.—Pipe System.

Extensions, etc	$ 9,899	78

2.—Meters.

New meters and setting	$ 481	26
Total paid on construction	$ 10,381	04
Paid previous to May 1, 1883	446,509	82
Cost of works to date	$456,890	86

MAINTENANCE AND OPERATION OF WATER WORKS.

1.—Pumping.

Salary Engineer	$ 1,200 00
“ Assistant Engineer	900 00
“ First Fireman	600 00
“ Second Fireman	557 50
“ Third Fireman	549 00
Fuel	4,742 45
Repairs to Pumping machinery	177 31
“ Boilers and Arches	1,036 36
“ Engine House	21 76
Supplies, (oil, packing, etc.)	448 11
	$ 10,232 49

2.—Office and Collecting.

Salary Collector	$ 750 00
“ Assistant Collector	499 92
Stamps and printing	62 75
	$ 1,312 67

3.—Superintendence and Repairs.

Salary Superintendent (3 months)	$ 75 00
“ Foreman of Repairs	840 00
	$ 915 00

1.—Iron Pipe.

Labor	$142 95	
Material	13 60	
		156 55

2.—Wyckoff Pipe.

Labor	$529 86	
Material	24 34	
		554 20

Amounts forward		$13,170 91

3.—PUMP LOGS.

Labor		111 68

4.—VALVES.

Labor	$209 71	
Material	174 00	383 71

5.—HYDRANTS.

Labor	$250 64	
Material	216 47	467 11

6.—METERS.

Labor	$228 84	
Material	66 51	295 35

7.—RESERVOIR.

Labor		60 62

8.—SETTLING BASIN.

Labor	$27 00	
Material	25 72	52 72

9.—SUPPLY CREEKS.

Labor	$305 47	
Salary Watchman	334 75	640 22

Amounts forward		$15,182 32

10.—SERVICE CONNECTIONS.

Labor	$180 85	
Material	759 75	
		940 60

11.—MISCELLANEOUS.

Tools	$198 30	
Blowing off	21 25	
Horse and Wagon	427 87	
Shop	103 30	
		750 72
		$ 5,328 48

RECAPITULATION.

Pumping	$ 10,232 49
Office and collecting	1.312 67
Superintendence and repairs	5,328 48
Total paid for maintenance and operation,	$ 16.873 64
Paid previous to May 1, 1883	$ 88.069 33
Total paid to date	$104.942 97
Income for the year	24.636 59
Cost of maintenance and operation	16,873 64
Excess of receipts over expenditures	$ 7,762 95

METERS.

Twenty meters have been added during the year, the total number now owned by the city being 375, of which there are set and in operation 338 of the following manufactures:

Ball & Fitts Rotary	197
Worthington	7
Crown	67
Ball & Fitts Piston	67

There are in the repair shop as follows:

Ball & Fitts Rotary	21
Worthington	1
Crown	4
Ball & Fitts, Piston	11
Total	37

There is in use one Undine, which is running on trial.

LEAKS ON DISTRIBUTION MAINS.

The following table shows the number, cause and location of the various leaks on the mains during the year:

NAME OF STREET.	Kind of Pipe	In.	Mouth	Day	Cause.
Louis	Wyckoff	4	May	8	Joint.
Bronson	Pump Log	6	"	9	"
Fountain	"	6	"	25	Split.
Campau alley	Wyckoff	4	June	5	"
East Fulton	"	10	"	11	Joint.
Scribner	"	8	"	14	"
Scribner	"	8	"	15	"
Bronson	Pump Log.	6	July	10	"
South Ionia	Wyckoff	6	"	11	Knot hole.
Fulton	"	10	"	13	Holes.
Barclay	Pump Log	4	"	17	Joint.
South Division	Wyckoff	12	"	18	"
North Canal	"	8	"	19	"
North Division	"	10	"	20	"
Scribner	"	8	"	27	"
North Canal	"	8	"	31	Spongy.
Campau Alley	"	4	August	2	Taken out.
North Canal	"	8	"	8	Knot hole.
North Canal	"	8	"	13	Joint.
North Canal	"	8	"	15	"
Scribner	"	8	"	17	"
Broadway	"	12	"	20	"
Scribner	"	8	"	23	"
West Bridge	"	12	"	24	Knot hole.
Scribner	"	6	"	27	Joint.
South Front	"	6	"	29	Knot hole.
North Canal	"	16	"	30	Joint.
East Fulton	"	10	September.	17	"
Fountain	Pump Log.	6	"	25	Taken out.
Fountain	"	6	"	29	Joint.
Lower River Pipe	Iron	12	October	1	"
Supply Pipe	"	20	"	4	"

LEAKS ON DISTRIBUTION MAINS—*Continued.*

NAME OF STREET.	Kind of Pipe	In.	Month	Day	Cause
Mason	Wyckoff	16	October	5	Joint.
Fountain	Pump Log.	6	"	29	In plug.
Bronson	"	6	November.	5	Split.
Broadway	Wyckoff	12	"	8	Joint.
Wealthy avenue	Iron	8	"	10	"
Paris avenue	"	6	December	1	In plug.
Shawmut avenue	Wyckoff	6	"	11	Joint.
Ottawa	"	16	"	13	"
Scribner	"	8	"	26	"
Wealthy avenue	Iron	10	"	28	"
Lyon	Wyckoff.	14	January	15	"
Jefferson avenue	"	6	"	16	"
Fountain	Pump Log	6	February	13	Taken out.
Barclay	Wyckoff	14	"	19	Joint.
Cherry	Iron	6	"	26	In plug.
South Division	"	12	March	17	Split.
Bronson	Pump Log.	6	"	28	Joint.
Ransom	Iron	2	"	31	Split.
Wealthy avenue	"	10	April	3	Joint.
South Ionia	"	6	"	4	"
Quimby	"	6	"	10	"
North Canal	Wyckoff	16	"	16	"
Livingston	"	14	"	27	"

The total number was 55 against 37 the previous year and 55 the year before that.

The total length of water mains now laid is 26.35 miles; number of fire hydrants, 275; number of valves, 168.

Respectfully submitted,

FRED A. TWAMLEY,

Collector.

ENGINEER'S REPORT.

To the Honorable the Board of Public Works of the City of Grand Rapids:

GENTLEMEN:—I have the honor to submit herewith my annual report of the work done by the pumping engines for the year ending April 30, 1884. And in doing so it gives me much pleasure to say that the engines have performed their work remarkably well, and with but little or no repairs, and if no accident befalls them I think it is fair to presume that another year will pass with a record equally as good as this.

The average daily consumption for the year has been 1,533,781 gallons against an average the previous year of 1,224,366 gallons.

Total cost to raise one million gallons of water into reservoir, $15.95 1-10.

Total cost of fuel to raise one million gallons of water into reservoir, $7.98 4-100.

Total cost to raise one million gallons one foot high $0.10 22-100.

Total cost of fuel to raise one million gallons one foot high, $0.05 11-100.

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, amount of wood and coal burned and cost of the same:

MONTH.	Days Run.	Time Run	No. of Revolut'ns	Gal's of Water Pumped.	Cords of wood used	Cost of wood used	Lbs of Coal used.	Cost of Coal used.	Total cost of Fuel used.	REMARKS.
		H. M.								
May........	31	315—20	370,854	37,085,400	70	$115 50	100,400	$194 93	$310 43	
June	30	252—55	402,143	40,214,300	19	31 35	150,050	306 70	338 05	80 bushels Coke, $8.80.
July........	31	422—25	471,949	47,194,900			204,369	480 93	408 93	
August	31	463—45	524,490	52,449,000	220½	368 82			368 82	
September	30	399—50	446,305	44,630,500	185¾	318 88			318 88	
October....	31	350—30	364,401	36,440,100	168¾	299 21			299 21	
November.	30	351—25	381,325	38,132,500	187	337 45			337 45	
December.	31	386—45	434,447	43,444,700	182	333 75			333 75	
January...	31	482—20	540,000	54,000,000	250½	459 24			459 24	
February..	29	434—40	490,100	49,010,000	235¼	405 54			405 54	
March......	31	557—15	636,092	63,609,200	178	311 50	131,635	262 98	574 48	
April	30	487—00	551,533	55,153,300	102	179 37	67,550	139 16	318 53	
Total	366	50,042—10	5,613,639	561,363,900	1799¼	$3160 61	654,004	$1312 70	$4473 31	
Grand total									$4482 11	

The running expenses for the year have been

	Repairs	Supplies	Total.
George W. Thayer		$ 54 45	54 45
L. D. Putnam		11 15	11 15
Foster, Stevens & Co		45 95	45 95
Shriver, Weatherly & Co		3 93	3 93
E. G. Studley		40 81	40 81
Leonard & Ellis		138 90	138 90
Robinson, Letellier & Co	$21 76		21 76
Fred Maybury		35 00	35 00
Michigan Iron Works	52 31		52 13
C. A. Lathren	131 65		131 65
A. Leitelt & Co	47 87	1 97	49 84
Total	$253 59	$332 16	$585 75

Engineers' salaries	$2,100 00
Firemens' salaries	1,706 50
Fuel bought	4,649 84
Total	$9,041 09

Respectfully submitted,

DEMETRIUS TURNER,

Engineer.

CITY SURVEYOR'S REPORT.

CITY SURVEYOR'S OFFICE.
Grand Rapids, Mich., May 1, 1884.

To the Honorable Mayor and Common Council:

GENTLEMEN:—I have the honor to submit herewith the annual report of public improvements conducted by the Board of Public Works during the past year.

The following tables show the number, manner and cost of the street improvements which have been completed during the year, also the street improvements now under contract.

STREET IMPROVEMENTS COMPLETED DURING THE YEAR ENDING APRIL 30, 1884.

NAME OF STREET.	FROM	TO	KIND OF IMPROVEMENT.	Length in Feet.	Contract Price.	Inciden-tals.	Total cost.	Per Foot	CONTRACTORS.
East Fulton.......	Spring.	Waterloo......	Graded, paved with wood & stone.	1,100	$5,790 00	$170 20	$5,960 20	5 42	Joel Collins.
Fourth Avenue ...	South Division	Grandville	Graded, graveled, gutters paved..	2,656	5,200 00	259 10	5,459 10	2 06	" "
North Waterloo...	Monroe........	East Fulton..	Paved with wood................	1,070	2,025 00	127 78	2,152 78	2 02	" "
Alley bet. Clinton and Livingston..	East Bridge....	Hastings.......	Graded............................	500	350 00	44 20	394 20	76	" "
Ottawa...........	Monroe........	East Fulton....	Graded, paved with wood & stone	778	2,950 00	138 60	3,088 60	3 96	J. C. Murray.
Pearl.............	Ottawa........	North Ionia....	" " " " "	264	1,525 00	72 22	1,597 22	6 05	" "
Davis.............	Fourth.........	West Leonard.	Graded and graveled.............	4,189	5,972 00	103 84	6,075 84	1 45	C. Prange.
Pleasant..........	South Division	So. Lafayette..	Graded, graveled, gutters paved..	1,497	3,000 00	116 70	3,116 70	2 08	B. Livingston.
Brainard...... ..	East Bridge...	D., G.H. & M. rr	" " " " "	1,050	2,600 00	123 02	2,723 02	2 59	P. J. Britton.
Fountain..........	Prospect.......	E. City Limits.	Paved gutters, repaired road bed.	2,835	2,600 00	210 88	2,810 88	99	Joel Collins.
Lagrave...........	East Fulton ..	Maple.........	" " " " "	1,732	1,950 00	148 70	2,098 70	1 21	J. B. Mathewson
Alley bet. N. Ionia and Ottawa......	Bronson........	East Bridge....	Graded and paved with stone.....	524	773 00	41 32	814 32	1 55	C. Prange.
Sinclair...........	East Bridge....	Hastings	Graded, graveled, gutters paved..	631	1,550 00	103 82	1,653 82	2 62	P. J. Britton.
Winter............	West Bridge...	Shawmut......	Graded and graveled.............	1,582	3,095 00	93 04	3,188 04	2 01	C. Utes.
Huron............	Canal..........	Lock	Graded and paved with stone. ...	168	445 00	56 08	501 08	2 98	A. Wiseman.
Hastings	Clinton........	College	Graded, graveled, gutters paved..	2,645	6,966 00	102 36	7,068 36	2 67	A. Wiseman.
Bank	East Bridge....	Squires' Alley.	Graded and graveled............	278	421 39	34 43	455 82	1 64	J. B. Mathewson
Hovey.............	Straight........	Shepard........	Graded, and graveled with best material in street.	1,259	1,850 00	51 60	1,901 60	1 51	C. Utes.
Dayton.......	Straight........	Shepard...	Graded and graveled with best material in street................	1,263	1,580 00	66 24	1646,24	1 04	B. Livingston.

Peaslee............	Straight.......	Shepard	Graded, grav.l'd best mat'r'l in st.	1,260	$1,700 00	$ 76 24	$1,776 24	1 41	C. Prange.
Island...............	South Division	Sheldon.......	Graded, graveled, gutters paved..	242	643 00	47 84	690 84	2 89	C. Prange.
Holbrook	Packard.	East.	" " " " ..	427	929 00	42 00	971 00	2 27	Wagemaker & Kloote.
Street at Reservoir	Clinton........	Livingston.....	" " " " ..	600	1,870 00	......	1,870 00	3 11	" "
Second............	Stocking.......	Michigan	Graded and Graveled.............	538	726 00	42 60	768 60	1 43	C. Prange
Alley blk 3 Ellsw'th	Goodrich	Bartlett........	Graded and Graveled..	275	675 00	46 60	721 60	2 62	" "
Ottawa......	Pearl	Lyon..	Graded, paved with wood & stone	251	1,445 00	85 93	1,530 93	6 09	" "
McConnell.........	South Division	South Ionia....	Graded, graveled, gutters paved..	594	980 00	106 25	1,086 25	1 83	B. Livingston.
Ninth.............	Fremont	Alpine avenue.	Graded, grav'l'd best mat'r'l in st.	812	560 00	66 88	626 88	77	" "

STREET IMPROVEMENTS NOT COMPLETED DURING THE YEAR ENDING APRIL 30, 1884.

NAME OF STREET.	FROM	TO	KIND OF IMPROVEMENT.	Length in feet.	Contract Price.	Estimated Incidentals.	Total Amount.	CONTRACTORS.
Second avenue....	South Division	Grandville.....	Graded, graveled, gutters paved..	2,322	$4,994 00	$276 00	$ 5,270 00	Doran & Pierce.
Page..............	Plainfield......	North avenue .	" " " " ..	1,738	3,970 00	240 00	4,210 00	B. Livingston.
James.	Cherry....	Wealthy " .	" " " " ..	1,320	4,607 00	113 00	4,720 00	C Utes.
North Front.......	West Bridge...	N. end of street	" " " " ..	7,167	14,440 00	460 00	14,900 00	A. Wiseman.
Monroe............	Spring.........	Pearl..........	Re-paving with wood and stone ..		3,928 25	171 75	4,100 00	Prange & Mathewson.
Canal......	Pearl..........	Bridge........	" " " " " ..		4,625 00	375 00	5,000 00	" "
Pearl..............	W. line Canal .	E. line Monroe	" " " " " ..		721 00	69 00	790 00	" "
North Division....	Monroe	Lyon.	Re-paving with wood............		,974 00	226 00	2,200 00	A. C. Sekell.
Coldbrook.	Canal..........	E. line Taylor..	Repair roadbed with wood & stone		1,574 00	106 00	1,680 00	" "

STREET AT THE RESERVOIR.

It was decided by the Board to take such steps as would insure perfect protection to the force main, leading to the reservoir in Mason street,(the scene of the washout which occurred September 2, 1880,) by extending Clinton street from the south line of the reservoir ground on said last mentioned street, across said ground to Livingston street north of the reservoir.

The improvement consisted of grading, graveling and paving the gutters of the street. To avoid making too deep a cut through the high ground at the point nearest the reservoir, the grade established was such as to convey the water from the center toward each end of the improvement. At its junction with Clinton street catch basins were constructed and connected with a 12-inch tile sewer laid in the street, from this point to the deep excavation in Livingston street, at the northern end of the improvement.

All the material excavated was deposited in Mason street, where the wash-out occurred.

As a further protection in the event of the sewer becoming in-operative, the sidewalk on the west side around to the summit of the grade, was kept above the highest point in the street, forming a dam against the flow of storm water down Mason street, to the further injury of the main.

SEWERS.

The extension of the Fulton and Washington street sewer west to the river was effected prior to April 30, 1883, as shown by the report for that year. During the low stage of the water last summer this work was completed by laying the iron pipe for conveying the sewage into deep water in the channel of the river.

While the water in the river remained below the outfall of the sewer, the sewage was discharged at a point beyond all danger of its becoming a nuisance.

There was expended for the pipe and laying the same, together with some incidental work, $1,237.40.

The entire cost of this work thus far has been $3,962.21.

Plans for the completion of this scheme, which is the interception of the sewage in the Monroe, Pearl and Lyon street sewers have been prepared and a contract for their execution awarded to A. C. Sekell for the sum of $3,865.

Adding to the above the cost of the iron pipe to be laid, there will be quite a balance to the credit of the Fund.

The entire length of the sewerage system is 27.591 miles, as shown below:

Brick Sewers	11.325	miles.
Vitrified Pipe Sewers	13.933	"
Cement " "	.480	"
Wood "	1.853	"
Total	27.591	"

SEWERS COMPLETED DURING THE YEAR.

Sewers completed during the year and those still undor contract are shown by the following tables, which also shows their location, etc.:

SEWERS COMPLETED DURING THE YEAR ENDING APRIL 30, 1884.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man-holes.	Catch Basins.	Length in Feet.	Contract Price.	Inciden-tals.	Total Cost.	CONTRACTORS
Jefferson avenue....	From 18 ft. s. of Morrison st. to sewer in Wealthy ave , also from n.l. Morrison to sewer in Cherry	12 in glazed pipe. 9 " " "	 4	 4	1052 226	$1,175 75	124 70	$1300 45	A. Rens.
Ottawa......	From 25 ft. n. of Fairbanks to sewer in Newberry	9 " " "	1		520	345 00	106 00	451 00	J. C. Murray.
Jefferson	From n. line Veto to sewer in West Fulton.......	9 " " "	2		380	338 00		338 00	A. Rens.
Alley blk 7, Bostwick & Co.'s addition.. ..	From Goodrich to sewer in Wealthy ave..........	9 " " "	1	1	374	278 00	82 83	360 83	A. Rens.
Alley bet Summer and Mt. Vernon sts......	From 200 ft. s. of Allen to sewer in Bowery st....	9 " " "	2		615	414 90	95 92	510 82	A. Rens
Fairbanks.............	From N. Ionia to sewer in Kent alley.....	12 " " " 9 " " "	 3	... 7	472 220	1,113 00	158 07	1271 07	L. Schneider.
Trowbridge	From N. Ionia to sewer in Kent alley	16x24 Brick. 12 in. glazed pipe. 9 " " "	 3	 7	183 284 290	1,100 00	89 07	1189 07	J. Collins.
West Leonard........	From N. Front to sewer in Broadway	16x24 Brick.	3	5	875	1,240 00	178 75	1418 75	Wagemaker & Kloote.
Alley bet So. Division and Spring	From Bartlett to sewer in Goodrich..............	9 in. glazed pipe.	1		325	248 00	57 82	305 82	L. Schneider.
Alley blk 11 Scribner & Turner's addition.	From 150 ft. n. of Fifth to sewer in Fifth..........	9 " " "	1		183	105 00	45 17	150 17	A. Rens.
Alley blk 9 Scribner & Turner's addition ...	From 50 ft. s. of Fifth to sewer in Fourth.........	9 " " "	1		3 7	162 00	50 81	212 81	McDermott & Martin
Alley blk 8 Scribner & Turner's addition...	From 160 ft. n. of Third to sewer in Third........	9 " " "	1		210	140 00	38 27	178 27	L. Schneider.
Alley blk 9 Bostwick & Co.'s addition. ..	From 60 ft. s. of Maple to 20 ft. s. of Goodrich	9 " " "	1		427	319 00	51 93	370 93	J. C. Murray.
Alley rear of lots 6 to 11 inclusive, of Pettibone's addition......	From Pettibone to sewer in Fremont........	9 " " "	1	1	378	200 00	43 53	243 53	A. Rens.

S. Spring......	From 30 ft. n. of Wealthy to sewer in Goodrich...	9 in glazed pipe.	1	1	299	$ 289 00	75 08	364 08	J. C. Murray.
Alley blk 11 Ellsworth addition............	From sewer in Bartlett south on Almy near W. gutter to alley in centre of blk, thence w. in said alley to n.&S. alley in said blk, then branching N.& S. to points 35 ft. n. of Goodrich and 35 ft. s. of Bartlett............................	9 in glazed pipe.	2		740	298 00	112 90	410 90	J. C. Murray.
South Division........	From 25 ft. n. of Green to sewer in Fifth ave.....	18x27 Brick. 16x24 " 12 in. glazed pipe. 9 " " "	6	9	645 655 677 120	4816 00	724 54	5540 54	A. Wiseman.
Bowery................	From Gold to sewer in Jefferson.................	9 " " "	1		314	170 00	32 26	202 26	J. Collins
North Front..........	From 35 ft. s of 11th to sewer in 8th st	12 in. glazed pipe. 9 " " "	2 ...	2	650 399	947 25	177 20	1124 45	A. Rens.
Alley bet. S. Division and S. Spring	From Oakes to sewer in Island....................	9 " " "	1		442	450 00	73 10	523 10	J. Collins.
S. Division & Wealthy avenue...............	In S. Division from s. line Wenhem avenue n. to Wealthy ave e. in. Wealthy avenue to Cass....	26x39 Brick.......	7	10	1838	7200 00	1450 67	8650 67	J. Collins.
North Front...........	From 25 ft. n. of Second to sewer in Fourth......	12 in. glazed pipe.. 9 " " "	2 ...	2	414 311	598 00	112 59	710 59	J. Collins.
Grandville avenue.....	From Summit to Sewer in Prescott	12 " " "	4	4	1391	1590 00	170 19	1760 19	C. Utes.
Second avenue........	From 100 ft. w. of S. Division st. to sewer in Buchanan st	12 " " " 9 " " "	3		186 1007	843 00	145 00	988 00	Utes & Schneider.
Alley bet. S. Division and S. Spring........	From 50 ft. s. of E. Fulton to sewer in Island....	9 " " "	2		274	275 00	58 48	333 48	J. Collins.
Alley bet Summer and Winter..............	From 25 ft. s. of Valley to sewer in Allen.........	9 " " "	2		417	340 00	86 44	446 44	L. Schneider.
Ottawa	From 25 ft. n. of E. Bridge to sewer in Hastings.. From 40 ft. n. of Hastings to sewer in Trowbridge From 27 ft. n of Trowb'ge to sewer in Fairbanks.	9 " " "	4		1561	1119 00	111 37	1310 37	J. Collins.

SEWERS UNDER CONTRACT AND NOT COMPLETED APRIL 30, 1884.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man-holes.	Catch Basins.	Length in Feet.	Contract Price.	Estimated Incidentals.	Total Amount.	CONTRACTORS.
Washington st. sewer extension..	In Washington st. from W. line Madison ave. N. on curve to N line said Washington st., thence n. e. across private property to College ave., at a point 312-5 feet n. of Washington st..........	18x27 Brick.	2	1	882	$1,982 82	$ 337 18	$ 2,320 00	A. Rens.
Alabama	In W. Bridge from sewer in Winter w. to Alabama, thence n. to 50 ft. s. of Third	16x24 Brick.	4	....	185	1,124 00	156 00	1,280 00	A.C. Sekell.
		12 in. glazed pipe.	....	....	410				
		9 " " "	....	....	684				
Alley blk 11-12 Scribner & Turner's addition.	From 160 ft. s. of Sixth n. to sewer in Seventh....	12 in. glazed pipe.	2	....	263	240 00	50 00	290 00	J. Collins.
		9 " " "	....	....	226				
W. Leonard & Alpine avenue	In W. Leonard from Davis to Alpine ave, n. in Alpine ave. to n. city line.	24x36 Brick.	....	....	640	7,693 00	957 00	8,650 00	C. Prange.
		20x30 "	5	8	647				
		18x27 "	....	....	658				
		16x24 "	....	....	805				
		12 in. glazed pipe.	....	....	515				
Winter st. sewer extension in Broadway	In W Bridge from Winter st. sewer to Broadway n. in Broadway to n. city line............	12 in. glazed pipe.	....	....	1410	25,547 00	1,203 00	26,750 08	McBrian & Farr.
		20x30 Bric .	....	....	1222				
		30x45 "	....	....	1311				
		41x53 "	18	40	1303				
		56x72 "	....	....	2804				
Seventh and Davis....	In Seventh from Broadway sewer w. to Davis, n. in Davis to W. Leonard........................	30x45 Brick.	....	....	1330	15,775 00	725 00	16,500 00	C. Prange.
		40x53 "	7	8	1310				
		45x52 "	....	....	1550				
Wealthy ave extension	In Wealthy ave. from w. line of Cass to S. Lafayette, thence n. in S. Lafayette to Holland, thence e in Holland to S. Prospect, thence e. through private property to Buckeye, e. in Buckeye to Henry, thence e. through private property to e. city line.........................	28x42 Brick	....	....	410	8,880 00	530 00	9,410 00	J. Collins.
		20x30 "	12	18	306				
		18x27 "	....	....	659				
		16x24 "	....		2306				
		14x21 "	...	...	700				
Lane avenue and Fremont st...............	In Lane ave from Sibley st. ditch n. to W. Bridge e. in W. Bridge to Fremont, n. in Fremont to Fourth................................	28x42 Brick.	....	....	1636	8,500 00			J. Collins.
		24x36 "	9	8	442				
		20x30 "	....	....	364				
		18x27 "	....	....	306				
		16x24 "	....	....	392				

BRIDGES.

The bridge contracted for with the Morse Bridge Co., of Youngstown, Ohio, to be placed at Bridge street is not yet erected.

It was proposed to render the old piers useful by lengthening them sufficiently to receive the new bridge; but an investigation into their condition revealed them unsuitable for this purpose.

The Board decided upon the erection of entirely new piers of a superior quality of material and construction.

Plans for regular coursed dressed rubble masonry of bowlder stone, with timber ice-breakers, were prepared, and the contract for their construction awarded July 23, 1883, to James Higgins for the sum of $8,225.

Owing to the continued high water last season, and other causes, this work has not yet been completed.

ENGINE HOUSE NO. 8.

This house is located on the northeast corner of Jefferson and Veto streets.

The building is constructed after plans prepared by Wm. G. Robinson, Architect, of this city.

The structure, while of plain design, has red brick, cut stone and galvanized iron ornamentation, to a limited extent.

The office, hose tower, apparatus room and stable, with their closets, complete the arrangement of the first floor.

The dormitory and bath rooms are upon the second floor in front; over the stable is the hay-loft.

A small basement for fuel storage purposes extends under the office and hose tower.

The contract for erecting the house was awarded to H. E. Doren Sept. 8, 1883. The price for erecting the house was $6,176; grading the lot cost $291.75. For the plank floor in the apparatus room and stable, hard brick, set edgewise in a bed of concrete, was substituted, the cost of which was $230.97, making a total expenditure of $6,698.72.

WATER MAINS.

In August, 1883, a contract was awarded to C. Prange, to lay water-mains at a cost of $1,997.80.

The aim was to so distribute the pipe as to afford the greatest amount of fire protection with the length of mains to be laid. The smallness of the appropriation did not admit of very great extension of the pipe lines.

For the benefit of, and at the expense of the parties interested, a 4 inch main was laid in Second avenue. The amount expended was $267.46, which is to be refunded when there is money at hand for such extension. This work was done by the city.

A main was laid by J. B. Mathewson in Bronson street from Ransom street extending west into Crescent Park:

Table showing location, etc., of pipe laid during the past year, together with the number of valves and hydrants:

STREET.	FROM	TO	Size Inches.	Length in Feet.	Hy-drants.	Valves.
Canal	East Bridge	Trowbridge	8	1167	4	1
Trowbridge	Canal	Kent	8	305	....	..
South Division	Fifth Avenue	Evergreen	8	637	2	1
Quimby	Canal	Plainfield	6	1763	3	2
Seward	Fourth	Fifth	6	404	....	1
Fourth	Seward	Stocking	6	1275	3	1
Paris	End of Pipe	Wealthy	6	615	1	..
Jefferson	Blakely	Sycamore	6	1085	2	1
Bronson	Ransom	Crescent Park	6	422	....	1
Second	South Division	West	4	350	....	1
		Total		8023	15	9

The total cost of the above extensions was $10,103.48.

CRESCENT PARK.

The stone stairway has been completed. Its cost exceeded the contract price a small amount, on account of some changes in the plans that were found necessary. The entire cost of the work was $1,680.44.

The appearance of the stairway has been greatly improved by the addition of a hand-rail. The rail and supports are of gas-pipe, plain and substantial, and a great convenience to persons ascending the stairway. This addition was made at a cost of $60 by Shriver, Weatherly & Co.

To provide the water necessary to sprinkle the Park and supply the proposed fountain, four-inch pipes were extended north and south from the Bronson street main in the Park, and proper specials inserted for hydrant connections. The work was done in connection with laying the Bronson street pipe.

The following is the cost of the improvements completed during the year:

Street Improvements	$61,748 86.
Sewerage	28,226 31.
Water Mains	10,103 43.
Engine House No. 8	6,698 72.
Crescent Park	1,740 44.
Total	$108,517 76.

Respectfully submitted,

H. A. COLLAR,

City Surveyor.

RESIGNATION.

At a meeting of the Board of Public Works, held April 26, 1884, the following communication was presented:

To the Board of Public Works:

GENTLEMEN:—After a service of ten years as Engineer in charge of the Pumping Works, I find myself, physically, unable to longer perform the duties of the position. I therefore offer my resignation, to take effect on the first of May next.

In my judgment, Mr. Geo. E. Kirk, my assistant, who has so long been associated with me, is worthy of your consideration and favor. I know of no person more suitable or competent to be put in charge of the pumping machinery than he, and I trust you may see fit to reward him according to his merit.

Silas and George Barrows, who have served as firemen and watchmen, and assisted about the engines for several years, I have found to be good and faithful men.

In taking my official leave of a Board that has, for so many years, annually named me for the position I now propose to surrender, I desire to express not only my obligation but also my appreciation of the confidence that the Board has shown in my professional capacity and skill. My duties and responsibilities have been such, that although my active service may cease, my interest will remain where I have labored so long. If, at any time in the future, I can be of use, I desire the Board to feel that it will be to me a pleasure to render any service I can.

To each of the members of the Board I have to express my thanks for the kind consideration they have ever shown me. The severing of my official relations fill me with regret, but I shall take with me only the most pleasant recollections of you all. With sincere regard,

Yours, faithfully,

DEMETRIUS TURNER.

Grand Rapids, April 26, 1884.

On motion of Mr. Plumb the resignation of Mr. Turner was accepted, and the President was requested to place Mr. Geo. E. Kirk, assistant engineer, in charge of the Pumping Works, until further action of the Board in relation thereto. Adopted.

Mr. Emery submitted the following:

Whereas, The resignation of Demetrius Turner, Engineer in charge of the Pumping Works, offered in consequence of impaired health and an existing necessity for a release from the responsible duties that he has so ably discharged, with credit to himself and to the satisfaction of the Board of Public Works since its organization, therefore, be it

Resolved, That in accepting the resignation of Mr. Turner this Board avail themselves of the opportunity presented, to convey to him assurances of their high appreciation of the skill and fidelity that he has always exhibited in the discharge of the duties of his position, and to express to him their sympathy in the affliction that is upon him, and the pleasure they will have in the knowledge of his complete restoration to health and a continuation of his life of usefulness.

Resolved, further, That the letter of resignation presented by Mr. Turner, and the action of this Board in relation thereto, be entered in the records of its proceedings, and that the President be requested to communicate to Mr. Turner the action herein taken. Adopted.

INVENTORIES, MAY 1, 1884.

Pipe, etc., at Pumping Station:

3 pieces, 4 inch, 12 ft. long.
14 “ 6 “ 12 “
5 “ 8 “ 12 “
6 “ 10 “ 12 “
29 “ 12 “ 12 “
1 “ 14 “ 12 “
5 “ 16 “ 12 “
6 “ 20 “ 12 “
4 “ 6 “ 1 “
1 “ 6 “ 2 “
3 “ 6 “ 3 “
4 “ 6 “ 9 “
1 “ 8 “ 4 “
5 “ 8 “ 10 “
1 “ 10 “ 2½ “
2 “ 12 “ 2 “
3 “ 12 “ 3 “
4 “ 12 “ 4 “
5 “ 12 “ 11 “
4 “ 12 “ 6 “
1 “ 12 “ 8 “
2 “ 20 “ 10 “
1 “ 20 “ 6½ “
1 “ 20 “ 2½ “
1 Lot of 16 inch Wyckoff pipe, about 400 feet.

1 Lot old Wyckoff pipe, small size.
2 New Hydrants.
3 Ludlow Hydrants.
1 4 inch Hydrant Base.
1 Hydrant Base Plate.
1 10 inch Valve.
1 6 “ “
7 Iron Valve Boxes.
1 20 inch Flange Valve.
1 lot old Valve Box Covers.
1 12 inch Plug.
1 4 “ “
2 4 inch Sleeves.
1 6 “ “
12 8 “ “
1 10 “ “
2 14 “ “
2 16 “ “
2 20 “ “
1 Reducer Hub, ends 16-12.
1 Three Way, 12x12x6.
1 “ “ 12x12x4.
1 “ “ 10x10x6.
2 “ “ 4x 4x4.
1 Two-wheeled Derrick.

Stock and Tools at Pumping House:

200 cords Hemlock Slabs.
40 gallons Valvoline Oil.
20 “ Machine “
3 Spirt Oil Cans.
10 Drip Oil Pans.

1 5 gallon oil can.
2 2 “ “
1 1 “ “
1 Match safe.
250 lbs. boiler compound.

½ set of pump valves for south engine.
50 ft. 1½ in. hose and nozzel
20 ft. steam hose & coupling
6 brooms.
8 mops.
3 lanterns.
5 Boiler scrapers.
1 4 in. steam flue blower.
2 long valve wrenches.
4 common wrenches.
1 long socket wrench.
1 short socket wrench.
12 spanners.
2 large monkey wrenches.
4 small “ “
3 files.
1 steam guage.
4 glass tubes for air chamb’r
1 “ “ “ boiler.
3 2½ in. old globe valves.
2 2 “ “ “
2 1½ “ “ “
3 1 “ “ “
2 ¾ “ “ “
1 2½ “ brass coupling.
1 ¾ “ iron “
2 2 “ “ “
1 3 “ “ “
2 2 “ plugs.
7 2½ “ flanges.
3 2½ “ Tees.
1 12 foot eye bolt.
1 lot of old bolts.
1 stock and dies.
1 wheelbarrow scale.
1 coal wheelbarrow.
2,000 lbs. of coal.
2 door mats.
2 scoop shovels.
1 long handled shovel.
1 hand saw.
1 garden rake.
1 2½ inch hoze nozzel.
1 ¼ “ “ “
22 ft. of 2½ in. Gas Pipe.
10 ft. of 1¼ in. “ “
14 ft. of 1¾ in. “ “
13 ft. of 2¾ in. “ “
1 Brick trowel.
4 yards canvas.
1 vise.
1 water pail.
1 step ladder.
2 long ladders.
1 short ladder.
6 chairs.
1 dust pan.
2 hand lamps.
5 wall lamps.
1 brass oil pan.
1 1¼ auger.
4 small bits.
1 packing hook.
6 cold chisels.

Stock and Tools at Repair Shop:

4 Mathew hydrant valves.
4 Lowry “ “
3 “ hydrant valve castings
2 “ “ stand pipes.
5 “ “ castings.
2 “ “ iron stems.

21 “ “ brass stems.
1 “ “ “ valve.
2 “ “ heads.
7 valve stems, 4 inch.
6 “ “ 6 “
5 “ “ 8 “
2 “ “ 10 “
2 “ “ 12 “
1 “ “ 14 “
1 “ “ 16 “
2 lbs. hydrant drip springs.
2 glands.
4 hydrant extension bolts.
13 thimbles f'r Wyckoff pipe
25 iron bands with bolts.
3 1¼ inch flush hydrants.
3 large valve wrenches.
2 Lowry hydrant wrenches.
2 Post hydrant wrenches.
4 cut-off street keys.
70 iron service boxes.
48 corporation stops, wood pipe, ½ inch.
50 corporation stops, wood pipe, ⅝ inch.
48 corporation stops, wood pipe, ¾ inch.
20 corporation stops, iron pipe, ½ inch.
55 corporation stops, iron pipe, ⅝ inch.
25 corporation stops, iron pipe, ¾ inch.
10 corporation stops, iron pipe, 1 inch.
1 Crown meter, new.
3 “ “ old.
1 Worthington meter, old.
19 rotary Union meter, old.
11 piston “ “ “
1 drill press.
2 drills.
11 caulking irons.
6 saws.
2 pipe cutters.
1 cutter stock.
4 dies.
1 machine stock and die.
5 taps.
7 machine taps.
4 tapping drills.
20 tapping augers.
1 extension bit.
1 drilling ratchet.
2 braces.
1 breast drill.
2 washer cutters.
1 pipe plyers.
1 square.
1 draw knife.
3 crowbars.
1 claw hammer.
2 sledge hammers.
12 Files.
2 ice picks.
4 oil cans.
1 lead pot.
1 lead ladle.
4 lanterns.
1 pair dividers.
25 shovels.
12 picks.
1 large clamp.
2 small clamps.
1 bench vice.
6 pails.

1 screw driver.
2 hatchets.
1 jack plane.
3 pumps.
1 light derrick.
3 pulleys.
1 scraper.
2 pipe wrenches.
1 large monkey wrench.
1 small “ “
2 S wrenches.
1 steamer.
6 wheelbarrows.
1 saw set.
15 cold chisels.
2 wood chisels.
6 punches.
3 caulking hammers.
1 testing pump.
1 fire pot.
1 basket.

2 tape lines.
5 pairs of rubber boots.
40 screws for lowering pipe.
60 feet 1½ inch rope.
40 feet 1 inch rope.
20 lbs. solder.
100 lbs. sheet lead.
75 lbs. lead.
100 lbs. nails.
5 gals. coal tar varnish.
2 gasket irons.
1 lot old iron.
1 “ “ rubber.
1 “ “ hose.
1 “ “ pipe fittings.
1 “ “ bolts and nuts.
1 “ rubber packing.
1 “ hoop iron.
1 “ gasket yarn.
1 stove and pipe.
30 feet ¾ inch hose.

Tools, etc., at Reservoir:

2 sickles.
2 scythes.

3 rakes.
1 valve key.

Tools, etc., at Barn.

1 horse.
1 wagon.
1 sleigh.
1 harness.
1 shovel.

2 forks.
1 lantern.
500 lbs. hay.
300 “ straw.
20 bushels oats.

Furniture, etc., at Office:

1 counter.
1 desk.
1 standing desk.
1 letter press and stand.
1 stool.
1 map of water mains.
1 portfolio water maps.

1 case stationery.
1 “ reports.
2 cuspidores.
1 waste basket.
1 clock.
1 thermometer.
1 wardrobe.

Engineer's Office

Grand Rapids Water Works.

REPORT

—OF—

A. C. SEKELL, C. E.,

—ON AN—

Additional Supply of Pure Water.

1885.

Also a Report of the

BOARD OF PUBLIC WORKS,

TRANSMITTING THE SAME TO THE

COMMON COUNCIL.

Grand Rapids Water Works.

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GRAND RAPIDS, MICH.
Eaton, Lyon & Allen Printing Company.

1885.

REPORT

OF THE

Board of Public Works

TO THE COMMON COUNCIL,

ON AN

Additional Supply of Pure Water.

To the Honorable Mayor and Common Council:

GENTLEMEN:—At a meeting of the Board of Public Works of this city on the 7th day of June, 1879, the following preamble and resolutions were adopted, to wit:

"WHEREAS, The Common Council of the City of Grand Rapids, at a session May 6, 1879, authorized the City Surveyor to make all necessary investigations, surveys, plans, etc., to furnish full, complete, and if possible, satisfactory data, to enable the Board to prepare and submit to the Common Council and the public a plan for procuring an abundant supply of the best obtainable water for the use of the City of Grand Rapids; therefore,

"*Resolved*, That the City Surveyor be and is hereby instructed to examine and report to this Board plans furnishing all facts necessary to exhibit the best method and sources to procure an additional supply of pure water, and the probable cost of its introduction; and further, "*Resolved*, That the examination be made to embrace, as possible sources of additional supply: Lamberton Creek, Lamberton Lake, Grand River, Coldbrook Creek and lakes supplying the same, Indian Mill Creek, or any other sources that promise satisfactory results."

Pursuant to these resolutions, the then City Surveyor, Mr. A. C. Sekell, with his assistants, made during the seasons of 1879 and 1880 such investigations, explorations and surveys as were deemed to be necessary to furnish the information called for. The possible sources of additional water supply mentioned in the resolutions were each examined, also Reed's Lake, the Saddlebag Swamps and Green Lake. The result of these examinations and surveys are set forth in detail in the elaborate and able report of Mr. Sekell submitted to the Board in June, 1880, which report was printed and presented to your honorable body and the public later in the same season.

As set forth in the foregoing preamble, it was hoped that the data to be obtained by the Surveyor would enable the Board to prepare and submit to the Common Council and the public a plan for procuring an abundant supply of good water for the use of the city. The explorations and surveys were extensive and thorough, but a summing up of the net results did not inspire the Board with sufficient confidence in any of the sources of supply reported upon to warrant them in recommending any specific source, or plan, for the additional water supply, of which this city is so much in need. The information brought before them was of a discouraging character; the several supposed available sources of supply, each of which have at times had among our citizens its friends and advocates, were found, without exception, to be unsatisfactory in quality, and with one exception, Grand River, insufficient in quantity. It became more than ever apparent that the greatest prospective need of Grand Rapids was to be an ample supply of good water suitable for domestic use.

Some thought and consideration had been given to the plan of getting a water supply from large wells, to be sunk in supposed favorable locations, a method that has in some instances been successfully adopted where the amount required is less than in this city. This plan seemed to gain in favor until quite a general desire was expressed that something of this nature should be tried ; accordingly the Common Council, in its annual budget for 1884, incorporated in its estimates an item of $3,000 to enable the Board of Public Works to determine where a better water supply for this city can be found, and its probable cost.

In April last the Board invited Mr. A. C. Sekell to meet with them for the purpose of considering and finally determining in what way, and at what point experimental water tests could be made with the largest prospect of success. The able report submitted by Mr. Sekell to the Board in 1880 gave evidence of an interest in the subject therein presented, and of an ability to meet the demands of the situation, that secured to him the confidence of the Board, and entirely satisfied them that there was no occasion to go abroad for the services of an expert water engineer to aid the Board in determining upon the line of action it might be most expedient to adopt. No engineer can be brought here in whose professional skill in this work they would have greater confidence.

Among the various methods in use for obtaining a ground water supply, to which Mr. Sekell particularly invited the consideration of the Board, was what is designated as the gallery system. The annual report of the Water Commissioners of Columbus, Ohio, where this system has been put in successful operation, was carefully examined, together with its accompanying maps and diagrams, from which it was seen that we had territory that apparently embodied exceedingly favorable conditions. The Board visited and inspected the territory east of and adjoining the river, from the Nelson farm northerly for two miles, and were highly pleased with the surface indications. It was then determined to be expedient, before commencing the experimental tests, that Mr. Sekell should go to Columbus, that he might personally examine their system and gather useful information in relation thereto, and be better able to judge of the prospect of success here. The result of such visit and personal inspection of the Columbus works, made at the request of the Board, was assuring in the highest degree. A lease of territory, having a river frontage of one-half mile, was made with Mr. Robert Briggs, and work commenced under the immediate direction of Mr. Sekell. The history of this work, extending over a period of months, and the results that it is believed have been reached, are fully and ably presented in the report of Mr. Sekell to the Board herewith submitted, which, with the maps accompanying the same, furnish the evidence upon which rests the conclusions he reaches, and the recommendations he makes, to all of which the Board ask the careful consideration of the Common Council, and all citizens who feel an interest in the subject. The facts presented in Mr. Sekell's report to the Board in 1880 should be fully understood before taking up and arriving at conclusions in relation to the recommendations he makes in his report herewith submitted. The report of 1880 shows that there are no known sources of water supply for this city that meet the public requirements; the quality of the water is unsatisfactory; the quantity, except Grand River, is insufficient, hence we are pressed into the necessity of resorting to what may be regarded as somewhat unusual methods. The gallery system is being used with most satisfactory results, but it is not in such general use, neither can the sources of supply and the amount of water that can be secured with certainty be so definitely determined as to put this system entirely outside of and beyond the pale of experiment.

The Board have given this subject as faithful and careful attention as they are capable of. They see no way of providing this city with pure and wholesome water that will compare, in point of merit, with the proposed gallery system. They know the purity and healthfulness of the water that can be provided, barring hardness, to be the very best. Its quality will never deteriorate ; it will be unchangeable. The only possible doubt that arises, is as to the amount; the report submitted tells all we can know about that ; we have great confidence that it will be sufficient. We recommend that this city take the necessary steps to obtain its supply of water by means of the gallery system, on the territory, and substantially in the manner recommended in the report submitted. If the Common Council shall coincide with the view taken by the Board, we recommend that early action be had by your honorable body with a view of providing the necessary means to enable the Board to enter upon the work.

Water Bonds to the amount of $200,000, to be issued as wanted, should be authorized by popular vote, at a special election, of which notice should be given for at least thirty days, that citizens may have an opportunity of becoming fully informed on the subject. Five hundred copies of the report herewith submitted have been printed. Citizens who desire to read up the water supply question will be furnished this report at the office of the Board without charge.

Respectfully submitted,

GEO. W. THAYER,
GEO. G. BRIGGS,
W. D. STEVENS,
A. D. PLUMB,
D. E. EMERY,
Board of Public Works.

GRAND RAPIDS, MICH., May 9, 1885.

REPORT OF

A. C. Sekell, Civil Engineer,

ON AN

Additional Supply of Pure Water.

To the Honorable Board of Public Works.

GENTLEMEN:—At a meeting of your Board held on May 15, 1884, I had the honor to submit, at your request, certain suggestions in relation to an additional water supply, which were followed by further suggestions at meetings held on May 26 and 27. At a meeting held July 19, a resolution was adopted directing me to proceed with the experimental tests, designed to determine the practicability of the plan which had been suggested.

I now have the honor to submit the following report and accompanying drawings, with certain recommendations and other matter, which I deem important to a complete understanding of the questions involved.

The plan submitted involves the construction of an infiltration or collecting gallery about nine thousand feet in length, commencing about four hundred feet south of Lamberton Creek on the east side of Grand River, and continuing northerly nearly parallel with the river and about fifteen feet below its summer level. The gallery will be of oval cross-section, four feet wide and four feet nine inches high, the walls to be of brick eight inches in thickness.

From its northern terminus a cast-iron pipe extends northeasterly about one thousand feet to a circular well, designed to receive the waters of the great springs in that vicinity.

From a receiving well near the southern terminus of the gallery, the water will be pumped into a cast-iron main leading into the city, and connecting at several points with the present pipe distribution system. Reference to the accompanying plans will show these general features.

In the inquiry as to the value of the plan proposed three questions are of importance, relating to the quantity and quality of the water procurable, and the expense connected with the construction of the proposed works.

ESTIMATE OF COST.

I estimate the cost of the work herein proposed approximately as follows:

15,400 linear feet 24-inch main at $4.25	$ 65,450 00
9,000 " " of gallery at $9.50	85,500 00
Bulkheads and manholes	1,000 00
Iron main at north end	2,000 00
Engine house, well and foundations	20,000 00
Removing and setting up present machinery	4,000 00
Land and right of way	4,000 00
	$181,950 00
Engineering and incidentals, 10 per cent	18,195 00
Total	$200,145 00

QUANTITY.

The gallery proposed will be supplied by the continued infiltration or entrance through its permeable walls of ground water from the adjacent earth.

An examination of the plans will at once suggest the idea that, as the gallery not only lies within a few hundred feet of the river, and several feet below its lowest level, the water entering the gallery will be simply filtered river water. Many galleries or works of similar character have been built upon this theory. Experience, however, has demonstrated that water can be procured in this manner only in comparatively limited quantities.

It has been found that the water which filters from the river has a tendency to clog with silt and sedimentary particles the minute passages through which it passes, so that it may occur that filter galleries or basins designed to take water only from the river side, and giving satisfactory results at first, soon become practically inoperative by reason of this clogging or choking up of the channels through which the water finds egress from the river bed. This choking up process is all the more certain to occur when the river bed is not periodically cleaned off by the swift currents of floods.

On the other hand, while experience has shown that under such conditions as are found here, no rapid infiltration from any portion of the river bed could be long continued, and while the surveys show that until the ground water surface along the line of the gallery is artificially lowered six or more feet, no *tendency* to such movement or infiltration would be created, I would not insist, that in case the gallery water line be considerably lowered below the river, no absorption into its underlying porous beds would occur. I use the word "absorption" instead of "infiltration" to aid in expressing the extreme slowness of movement which might take place. There are more than 6,000,000 square feet of river bed along the line of the gallery. If only one-half of this area was in communication with porous beds lying within the influence of the gallery, and 3,000,000 gallons of water daily were actually derived from this source, the movement of the water as it receded from the river bed would not exceed *one and one-half inches in twenty-four hours*, or fifty feet in a year, a rate of motion that could not effect the slightest change in the normal condition of the river bed.

The ultimate source of all water supplies is the rainfall, or more accurately the aqueous precipitation, which includes rain, hail, snow, frost and dew. When water falls upon the surface of the ground, a certain part may sink through the upper layers of soil, pass below the reach of evaporation, escape the grasp of growing vegetation, and finally reach the underlying supersaturated earth, the water table, or, as it is sometimes called, the water spring, the surface of the ground water; it then commences to move laterally with extreme slowness until it reappears at the surface in springs or other open water at some lower level.

All true wells, large or small, open wells or driven wells, and all infiltration galleries taking water from the land side, are supplied with this ground water; so are all springs, and so also are artesian wells. There is a continued accession to the ground water surface from the annual rains, and the result of the ground water movement is the annual discharge of these accessions into surface waters at lower levels.

Upon the general map accompanying this report I have drawn a line intended to represent the limits within which the ground water would move or be drawn towards the proposed gallery; that is, to define its drainage area. If the annual percolation or ground water accession could be determined, the quantity of water which the gallery would furnish could be estimated with an accuracy depending upon the correctness of this boundary line. I have said that artesian wells are supplied from the ground water; such wells are commonly supposed to be, and often are, supplied from remote districts. It sometimes occurs that high-lying domes or ground water surfaces are found over permeable geological formations that range beneath impermeable formations in such a manner that a portion of the ground water escapes finally at some remote natural outlet. Such conditions occur in some of the chalk districts near London. There "all the water that has been absorbed upon the surface does not escape at lower (inland) surface levels. A large quantity filters down with the dip of the beds in obedience to gravity, and ultimately becomes, by hydrostatic pressure, forced out to sea."* It is proper, therefore, to consider what evidence, if any, exists that the ground water or some proportion of it, accumulated within the natural drainage area of the gallery, may not escape by such artificial outlets as are afforded by artesian wells, or sink into underlying permeable formations and be carried away to some distant natural outlet.

In an examination of the geology of the district there appears first the superficial formation of considerable thickness known as the drift. Underneath the drift masses will be found, first the Carboniferous Limestone formation, characterized by an exclusive limestone deposit throughout the upper part, and by beds of limestone separated by thin sheets of shale throughout the lower part. This formation is believed to be about fifty feet thick. I may say in passing that the particular locality under examination is shown upon the geological map of Michigan, very near the border of the carboniferous limestone, so that if the drift was removed it is possible that the characteristic sandstones and shales of the more recent coal measures would be first disclosed; the conclusions would not, however, be affected by this circumstance.

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* Lucas, Horizontal Wells, London, 1874.

The formation next in descending order is known as the Waverly Group, which has an approximate thickness of one thousand feet. The upper division of this formation is prevalently a sand rock, with subordinate layers of shale, and seams of sand rock cemented by much calcareous matter, the thickness of this upper division being from three hundred to three hundred and fifty feet. The lower division is chiefly a shale formation interstratified with arenaceous beds and seams of calcareous and ferruginous concretions.

These formations and those which immediately underlie them are the deposits from an ancient sea. The stratification is often discordant, but the beds still lie in a substantially horizontal position.*

The upper surface of the formation immediately underlying the drift is doubtless much eroded by the action of water; valleys, chasms and gorges resulting; and probably all the harder rock beds are much fissured and broken, while the shale beds, especially in the more recent formations, are not continuous over wide areas, but are continually thinning out or wedging into the beds of harder rock.

Reference to the sketch, Plate 2, which shows the sections of some of the deep borings which have been made in this vicinity, will show the relative position of some of these beds of rock. The effect of this geological arrangement from a hydrological standpoint is this: Underneath the drift we have a series of horizontal beds unbroken by faults or dislocations, all permeable but of a permeability differing highly in degree. Add to this, masses of porous overlying drift in which the domes and inclined planes of the ground water surfaces rise to a considerable height above the primary valleys, which represents the general case, and we have along the valley lines *precisely the conditions necessary for artesian wells of moderate depth*, and where such wells are bored the abstraction of the subterranean waters is promptly made good by a slight downward movement of the ground waters of the drift and a corresponding reduction in the yield of the surface springs. But the subjacent rock beds in this vicinity are of such a chemical character as to render the ground waters that have ranged through them absolutely unfitted for general use, they often issuing with upwards of three hundred grains of soluble salts per gallon; hence not only is the city precluded from seeking a supply in this way, but private enterprise as well. The amount of ground water that may be now, or is likely in the future to be abstracted in this way, is too small to receive further attention.

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* C. Rominger, Michigan State Geological Report.

Upon the sketch, Plate 2, showing the geological formations in this vicinity, will be seen a line showing the relative position of the sea level, and also the levels of Lakes Michigan and Huron. Below this upper line all strata are of necessity in a state of supersaturation, and further, there can be no lateral movement along these horizontal beds unless there is sufficient difference in elevation or pressure maintained between the extremities of the movement to overcome the resulting friction, just as water cannot move in an inverted syphon unless it stands higher in one leg than in the other.

The bottom of the proposed gallery is about ten feet higher than the level of the lakes, and this difference or head is not sufficient, in my opinion, to produce any undesirable horizontal movement through thirty miles of geological formations, be their permeability what it may.

Nor can this horizontal movement occur in the direction of the river valley, because the water which rises in the artesian borings in the city will, I think, without exception, rise many feet higher than the level of the gallery. I conclude, therefore, that no water within the drainage area escapes into the underlying formations to be carried to some remote natural outlet.

We come now to examine some of the characteristic features of the ground waters of the drift.

Drift masses, such as are found in this locality, are made up of sand, gravel, stratified clay and boulder clay. When these members are found imposed in what is considered to be their natural order, as in some parts of Canada and in Scotland, we have—

Superficial sand and gravel.
Stratified clay.
Till or boulder clay.

The boulder clay or hardpan covering the underlying rock in an unbroken sheet, often of great thickness in valleys, and thin or wanting on hills. The boulder clay is a heterogeneous mixture of sand, gravel, pebbles, small boulders and clay, which, when submitted to the action of water, may be separated and deposited in regular stratified beds; hence the conclusion that the boulder clay was the original deposit, and that afterwards it was subjected to the modifying action of water, which produced the sand, gravel and stratified clay beds which are known as the stratified or modified drift.

As the boulder clay is impermeable, and may exist in extensive sheets, it is important to inquire as to how far its existence within any given area may be likely to introduce an element of uncertainty into the direction of the ground water movements, and the location of the line defining the drainage area.

In the Annual Report of the Michigan State Board of Health for 1877 may be found replies from thirty-nine correspondents of the board, representing as many different localities in the state, in answer to this question: "What is the nature of the soil and geological formation in your location?" From these thirty-nine localities there are replies that would indicate the existence—

Of boulder clay next the rock	0
Of stratified clay next the rock	7
Of probably stratified clay next the rock	2
Of sand and gravel next the rock	5
Of probably sand and gravel next the rock	11
Doubtful	14

In this city boulder clay is rarely found next the rock, so far as I can learn or have observed. In the test wells sunk during the past season along the line of the gallery a mass of boulder clay was encountered which is perhaps one thousand feet in length; three wells were sunk through it, and porous strata found below in each case.

It seems to me probable that the modifying influences which produced our stratified drift were very thorough in their operation, and that but comparatively little of the original deposit of boulder clay was left undisturbed. The stratified clay beds are not continuous, and, so far as I have seen, they are in this locality generally of small extent, and almost always underlaid by stratified sand or gravel.

I conclude, therefore, that in examining into the probable movements of the ground water, the drift, taken as a whole, may be considered as a permeable formation, generally homogeneous. In any district composed of heavy masses of a homogeneous, permeable deposit, such as sand or gravel drift, lying generally higher than the ground water and not traversed by denuded valleys, the following state of facts will be found:

First. The ground water surface, which may be an inclined plane, or a part of a low-lying dome, will rise as we recede from the open water that determines its lower edge, until a summit is reached, from which the surface will descend to some other valley line;

Second. The rates of inclination will be found depending upon the annual accession from the rainfall, the resistance of the strata traversed, and the distance from summit to valley;

Third. The ground water surface will be found to be in no way influenced by the configuration of the overlying surface of the ground; and,

Fourth. Whenever the surface line dips or cuts below the ground water surface a pond or lake results.

So far I have considered the effect of such conditions as prevail almost exclusively over the northerly portion of the area naturally tributary to the proposed gallery.

When the land surface has an inclination generally less than is necessary for ground water movements, a general condition, the ground water is of necessity forced out in springs and streams, from which result denuded valleys. When to this last named condition is added the further fact that the drift is not entirely permeable, but that its sand and gravel beds are often separated by sheets of clay, an assumption is reached which accords with the conditions found in the southern and southeastern part of our drainage area; that is, in the valley of Lamberton Creek.

Under the last named conditions the surface of the true ground water is often obscure, losing its smooth, unbroken character, and presenting many discordant features. False or secondary water tables will often occur, sometimes appearing as ponds or swamps of considerable size many feet above the true ground water plane, and in many places miniature artesian wells become possible. I wish, however, to emphasize the fact of the general existence of these low-lying domes and inclined planes; to show that even under the most complex conditions arising from a preponderence of impermeable sheets the constant tendency of the ground water surface is towards the more simple forms suggested, and that its movements are better illustrated by broad, slow-moving surfaces, than by rapidly-moving veins and threads.

In attempting to define the drainage area of the proposed gallery, I have acted upon the theory, so far as its northern and southern limits are concerned, that the drift within the area is practically homogeneous and permeable, and without denuded valleys that furnish means of escape for surface waters; but in defining the eastern boundary I have followed, as near as practicable, the present summit of the ground water, without supposing that the influence of the gallery will ever extend further east.

In thus fixing upon this arbitrary limit two important factors are not to be overlooked, first, the surface escape of the flood waters of Lamberton Creek valley, which I have provided for in assigning a numerical value to the annual infiltration in this part of the area; and, second, the fact that a large part of the ground water which has its origin in this valley escapes into the creek, or into lakes at its head. It is certain, however, that a large part of this will sink through the gravelly bed of the creek wherever it runs over strata that are within the direct influence of the gallery. The creek bed is well adapted to promote such action, being periodically scoured by the flood waters of storms. This reabsorption process could be readily extended by artificial measures so as to utilize, if desired, the entire volume of the stream except during floods.

The area included within the boundary lines drawn on the map is six thousand five hundred acres.

RAINFALL AND INFILTRATION.

The following table, prepared from a complete record furnished by Mr. L. H. Streng, of this city, exhibits the annual and monthly average rainfall in this city for the past fifteen years:

RAINFALL AT GRAND RAPIDS.

YEARS.	Total Fall in Inches.	MONTHLY AVERAGE DURING PERIOD.			
		MONTH.	Average Rainfall.	RATIO.	Av. No. of Rainy Days.
1870	36.86				
1871	30.95				
1872	33.47				
1873	41.80	January	2.75	.88	17
1874	29.02	February	2.71	.86	14
1875	33.40	March	2.89	.92	15
1876	35.25	April	2.67	.85	11
1877	31.83	May	3.01	.96	12
1878	35.75	June	4.66	1.49	12
1879	29.94	July	3.56	1.14	10
1880	45.27	August	3.02	.97	9
1881	45.34	September	3.36	1.07	11
1882	40.76	October	3.65	1.17	12
1883	50.84	November	2.76	.88	14
1884	43.41	December	2.55	.81	17
Average..	37.59	Average	3.13	1.00	13

The maximum rainfall is in excess of the average 36 per cent.

The minimum rainfall is in defect of the average nearly 23 per cent.

The average of the three dryest consecutive years is 32.50 inches, or about 15 per cent. less than the general average.

The average monthly rainfall exhibits two minima occurring in April and December, and two maxima, a principal one in June, a secondary one in September.

The station at which these results were obtained is in the north part of the city, about four miles south of the proposed gallery. I know of no reason why the rainfall would materially differ in the two localities.

It is impossible to arrive at any very satisfactory conclusion as to the annual quantity of water that will traverse the surface soil and reach the ground water. The subject is involved in obscurity, and the experiments that have so far been made are not sufficiently complete and extended to permit of their general application.

When rain falls upon the ground a portion may escape over the surface into streams or lakes, while another portion may sink into the underlying strata. Of the water which descends a part may be retained in the surface layers of soil, and thus exposed to the influence of vegetation and evaporation.

The absolute quantity of water which escapes these influences and finally descends to the water table, depends upon the frequency and intensity of the rains, the retentive and absorbent qualities of the soil and the strata immediately underlying, the surface covering, extent and character of the vegetation, the prevailing winds, temperature, sunshine, humidity of the atmosphere, and physical configuration of the surface.

Should the quantity of fallen rain be little, the entire amount may be retained in the upper layers of soil to be subsequently evaporated or absorbed by growing vegetation. If, however, rain continues to fall so that the upper layers become sufficiently saturated, a portion of the water will descend to a point beyond the reach of evaporating influences.

As illustrative of the retaining power of various soils, it has been found that one hundred pounds of dry soil will not drip until it has absorbed, if a—

Calcareous sand,	29	pounds of water.
Loamy soil,	40	" " "
Clay loam,	50	" " "
Pure clay,	70	" " "

Of the many complex influences that affect the question of infiltration perhaps the most important therefore are: first, the order or natural sequence of the rains, whether the showers are so small in amount as to seldom produce that supersaturated condition of the soil, without which no considerable infiltration can occur with intervals such as would give full effect to adverse agencies, or whether the rains are of a more tropical character, with longer intervals of drouth, during which the effect of evaporation and vegetation are reduced for want of moisture upon which to operate; and second, the ability of the upper layers of soil to retain water and thus expose it to the vaporizing inflences of evaporation, combined with the freedom with which the descending water can traverse the underlying subsoil.

A heavy rain falling upon a sandy soil covered with the decaying products of vegetation and underlaid with loose sands or gravels, would be almost entirely absorbed and added to the ground water, while the same rain falling upon retentive soil, such as a clay loam, would be retained in the upper layers, and thus lost.

Of the total drainage area under examination there are approximately as follows:

Sandy soil with porous subsoil,	72	per cent.
Clay soil,	19	"
Swampy surfaces,	7	"
Water surfaces,	2	"

The wooded lands are about 10 per cent. occupied almost entirely by sapling white oak. Of the entire area there are surfaces so situated that waters may escape by surface drainage, about 42 per cent., while from about 58 per cent. of the area no surface waters can thus escape, the surface of the ground being exceedingly broken by a continued succession of depressions generally circular, and often of considerable extent, so that large districts present such a shape as could be made by laying a blanket over the flattened surface of a pile of boulders. Some of these saucer-shaped depressions are but a few feet in depth, while others dip more than seventy-five feet below the general level. This peculiar feature is of advantage, as whenever any movement of the water over the surface occurs it is all caught in these basins and very quickly absorbed.

The first important experiments looking to the direct determination of the annual infiltration were made by Mr. Dickenson, at Hertfordshire, England, commencing in 1836. The lysimeter used was three feet deep, sunk in the ground to a level with the surface, filled with soil and covered with growing grass. The filling was as follows: At the top a ten-inch layer of ordinary surface soil—a sandy, gravelly loam—then a thickness of about fifteen inches of sandy gravel gradually becoming coarser towards the main mass, which was clean, coarse gravel.* From the record which covers a period of thirty-four years, it appears that the annual evaporation exhibits a much less range than does the percentage of rainfall which infiltrates. I have, therefore, in analyzing the results, confined myself to the direct amount of evaporation instead of the ratio of infiltration.

The average rainfall during the thirty-four years was..... 26 24 inches.
The maximum rainfall was................ 41.14 inches.
The minimum rainfall was................ 16.96 "
The average annual evaporation was.................... 18.78 "
The greatest annual evaporation was....... 28.03 inches.
The least annual evaporation was.......... 13.25 "

The average annual infiltration was..................... 7.46 inches.

As the influence of evaporation and vegetation is much the greatest during the summer months, often in dry climates reaching the total rainfall, I have prepared the following table, which shows the number of summer periods of six months each during the thirty-four years when no infiltration occurred; also the number of summers when it was less than 0.20 inches, and so on:

No. of Summers.	Average Rainfall. Inches.	Approxim'te Infiltration Inches.
13	12.19	0.00
7	12.30	0.00 to 0.20
3	12.24	0.20 to 0.50
2	13.52	0.50 to 1.00
4	14.15	1.00 to 1.50
3	13.81	1.50 to 2.50
2	18.90	Over 2.50

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* Humber's Water Supply.

During the entire period there were no winters in which infiltration did not occur. The average winter evaporation was 6.85 inches.

From the results obtained during summers it would seem that 12.40 was very near the measure of the summer loss on gravelly loam soils covered with growing grass, and that, when the summer rains exceed this, infiltration occurs. This, however—assuming accuracy in the experimental results—expresses merely a general fact applicable to localities with lithological and climatic conditions similar to those prevailing at Mr. Dickenson's station. Nor could this conclusion be applied to every year or every term of three consecutive years.

The results that follow combinations of adverse circumstances, such as low rainfalls occurring when evaporation is greatest, must receive attention, and in doing this I shall consider, not the minimum rainfall of one year or the greatest evaporation of one year, but the results which were obtained in periods of three consecutive years. The reason for this I will state here, without any discussion of the subject. Briefly, it is because, in my opinion, the storage capacities of the porous strata contiguous to the gallery, which can be drawn on without immediate replenishing, are so great as to warrant it. I think that more than 1,000,000,000 gallons of water are held as free water in the porous strata in the "area of influence," and this quantity or storage capacity justifies the expectations which can be based on three year periods of minimum infiltration, which will always average greater than the single year minimum.

Turning again to the experiments at Hertfordshire, the average evaporation during those three-year periods, when it is excessive or at the maximum, never exceeded the general average by 20 per cent., and this excessive evaporation *may* occur when the rainfall does not exceed the average. Hence, if 20 per cent. be added to the general average evaporation, an expression will be reached indicating a safe limit for all three-year periods when the rainfall reaches or exceeds the general average. But minimum three-year periods of rain are less than the average; in England, almost exactly one-sixth.

The evaporation during three-year periods of low rainfall was

generally *less* than the average, and *never exceeded it by so little as two per cent.* Hence a safe limit for any works depending on infiltration, and having sufficient storage capacity, will be found in *the minimum three-years rainfall less the general average evaporation*, providing the lithlogical, climatic and surface conditions are similar to those at Mr. Dickenson's station in Hertfordshire.

Mr. Jos. Prestwich, in an exhaustive inquiry upon the "Water Bearing Strata around London, 1854," arrived at the following conclusions regarding the quantity of water that would *annually* percolate the surface soil covering the outcrop of several geological formations in the vicinity of London:

GEOLOGICAL FORMATION.	Total mean annual Rainfall. Inches.	Annual Evaporation. Inches.	Annual Infiltration-Inches
Lower Tertiary Sands	25	13	12
Upper Greensand	28	18	10
Lower Greensand	26½	10½	16½

In illustration of the actual evaporation and absorption from extended areas the following table, showing results derived from the remarkable drought of 1868, will be of value. It is from the evidence given by Mr. Bateman before the Royal Commission on Water Supply (1869):

NAME OF WATER-WORKS.	Mean Average Rainfall.	Area of drainage Ground. Square Miles.	PERIOD OF DROUTH. 1868.	Days.	Rainfall during Drouth.	Loss by Evaporation during Drouth.
Manchester Corporation	50.	29.6	Apr. 27 to Sept. 24	150	9.	6.23
Dublin	52.38	22.	May 1 to Sept. 18	141	11.29	6.92
Glasgow—Loch Katrine		71.	May 30 to Aug. 8	70	4.65	3.26
Glasgow—Gorbal's Dist.	49.	4.	March 29 to Oct. 3	189	18.19	11.74
Liverpool	46.	15.	Apr. 28 to Oct. 16	161	12.20	10.67

In no case does the loss by evaporation and absorption exceed that shown by the experiments of Mr. Dickenson, although the average rainfall in the several localities is much greater.

Dr. Dalton's experiments, made at Manchester, continued three years, and gave the following average results:

Mean annual rain	33.55
Average annual evaporation	25.16
Average annual infiltration	8.39

In these experiments Dr. Dalton used the common surface soil of the district (new red sandstone), which contains a good deal of clay, and would probably be very absorbent and retentive.*

Mr. Charnock's experiments, near Ferrybridge, Yorkshire, continued five years, with the following results:

Mean annual rain	24.60
Average annual evaporation	19.78
Average annual infiltration	4.82

The soil used was the heavier magnesian limestone soil of Yorkshire, and was much more argillaceous than that used in the other experiments mentioned; "and further, his experiments having reference to a special agricultural question, the soil was occasionally stirred."†

Mr. Thos. Hawksley, in his evidence before the Royal Commission, published in the Report of 1867, stated that in certain districts in England which are part low land and part high land, with an annual rainfall of forty-five inches, the evaporation will be about thirteen and a half inches. It will be observed that this amount which is stated as the result of actual experience, agrees almost exactly with the average evaporation which Mr. Prestwich believed would occur from his investigations made nearly fifteen years before.

During the past two years lysimeter experiments have been conducted by Dr. E. Lewis Sturtevant, Director of the New York Agricultural Experiment Station at Geneva.

The following table expresses the general results of rainfall and infiltration at Geneva, N. Y.:

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* Prestwich's Water Bearing Strata.

† Ibid.

RESULTS OF RAINFALL AND INFILTRATION.

YEAR.	Rainfall. Inches.	Rainy Days.	INFILTRATION.		Evaporation.
1883	25.89	135	On Sod	3.74	22.15
			Bare Soil	8.24	17.65
			Stirred Soil	11.51	14.38
			Average	7.83	18.06
1884	22.30	....	Sod	3.64	18.66
			Bare Soil	5.16	17.14
			Stirred Soil	5.98	16.32
			Average	4.93	17.37

The average annual evaporation from sod is about 10 per cent. in excess of that shown by Mr. Dickenson's experiments in England.

Infiltration occurred each summer, and during nearly every month. The difference between the summer rain and infiltration seems to indicate a summer-evaporation, on average surfaces, of about twelve inches, and on grass land about fifteen inches, amounts which agree very closely with the English experiments.

During winter months evaporation was nearly the same from the different exposed surfaces. The winter evaporation in 1884, taking the first three and last three months, was 6.28 inches, and in 1883 it was 5.33 inches, the average for the two years on all the surfaces exposed being 5.78 inches. This also agrees very closely with the experiments at Hertfordshire, where the average winter evaporation for thirty-four years was 6.35 inches.

Experiments made to determine the evaporation from surfaces of snow, near Boston, gave as a result an evaporation of 0.02 inches per day.* This would be for five months—about the time snow covers the ground in this vicinity—a trifle over three inches.

The evaporation from a large surface of water—Beacon Hill Reservoir—during the first four months of 1876, was 5.58 inches.†

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* Report of Boston Water Board, 1879.

† Report of Boston Water Board, 1877.

In attempting to combine the results of the foregoing experiments, and to apply them to the district under examination with its varied conditions of soil, surface, and surface covering, to give the right value to the effect of the differences in the many complex conditions of climate existing between the various localities where the results were obtained, I am aware of an insurmountable difficulty. The most that can be attempted is a general approximation intended to apply to those three-year periods when the annual average infiltration approaches the minimum. The result is shown in the following table, giving probable annual infiltration on drainage area of proposed gallery:

KIND OF SURFACE.	Acres.	Annu'l rain 3 year Minimum.	Annual Infiltration	Av. Gal. per Day.
Sandy Soils from which surface waters do not escape	3,800	32.50	18 in.	5,086,000
Other Sandy Soils............	900	"	13 "	870,000
Clay Loam	1,200	"	10 "	892,000
Marsh—Swamp..............	500	"	0	....
Water......................	100	"	0	....
TOTAL..................	6,500	32.50	....	6,848,000

In round numbers 7,000,000 gallons per day. This result is based upon the theory that the true ground waters flowing in Lamberton Creek will be absorbed as they flow over porous strata within the direct influence of the gallery.

The eastern limit of the drainage area I have placed, as stated before, at the present summit of the ground water dome, *although the conclusions respecting the homogeneous permeable character of the drift might justify its removal to a point considerably further east.*

No allowance has been made for any absorption by the porous beds under the river.

The plan submitted is intended to utilize substantially all the ground water obtainable in the district; that is to say, I have placed the northern terminus of the gallery at a point beyond which it cannot be profitably extended, owing to the course of the river beyond, as further extensions would not effect a corresponding increase in the area drained.

Should it be necessary in the future to add to the quantity which the gallery can continuously yield, undoubtedly the best plan would be found in the construction of a second gallery on the west side of the river connecting with the gallery on this side by an iron main laid in the river bed. Another method of increasing the yield would be found in permitting water from the river to flow at intervals over portions of the sand beds that lie along the line of the gallery.

I have discussed at some length the questions upon the solution of which depend the annual quantity of water obtainable by the method herein proposed, not only for the purpose of showing their application to the location of the gallery as designed, but also for the purpose of showing the futility of locating such works at any point remote from the river, which would of necessity involve either unwarrantable expense for construction, or such a reduction in available drainage area as would defeat the object sought.

During the past season nine large test wells have been sunk along the line of the southern portion of the gallery at intervals of a few hundred feet, the results from which, both as regards the character of the strata penetrated and the rate at which the water entered the excavations, are satisfactory, and, as far as possible, conclusive.

The sections of these wells are shown in the following table, which shows also the rate at which the ground water entered. For purposes of comparison merely, and not as indicating in any degree the ultimate capacity of the strata, I have also added the diameter of a well, which, at the same rate as the test well, would yield approximately 7,000,000 gallons per day.

The ordinary rate of artificial sand filtration beds is six inches per hour. The rate of the larger natural infiltration galleries is generally somewhat greater.

Should the gallery herein proposed be constructed, its 'rate' at 7,000,000 gallons per day would be about four and one-half inches per hour. The well marked as "1" is near the south terminus of the gallery; "9" is near the town line, and the others are intermediate. No exploration of the strata north of the town line has been made at present.

SECTIONS OF TEST WELLS, ETC.

NUMBER............	1	2	3	4	5	6	7	8	9
Section............	Soil... 1 ft Sand..15 ft	Muck........ 1 Yellow Sand. 3 Gray Sand... 8 Plastic Clay. 8 Gravel ...... -	Muck........ 3 Stony Soil... 1 Clay with veins of Sand....18	Muck........ 3 Sandy Gravel 5 Sand 10	Muck.... 4 Marl.. 13½ Gravel .. 2 Sand.	Muck.... 3 Marl ....10 Gravel .. 1 Sand .. 2½ Sand.	Muck........ 2 Marl....... 8½ Gravel..... 2½ Sand .... 1 Clay......... 1 Boulder Clay 4 Loose Gravel 2	Muck........ 3 Marl......... 6 Boulder Clay14 Fine red sand 2 Probably Rock	Muck........ 3 Loamy Grav. 6 Boulder Clay10 Compact Gr. 2
Approximate Size of Well, in feet....	10 x 17	8 x 15	6 x 16	9 x 11	9 x 16	9 x 16	9 x 16	9 x 16	16 x 16
Rate at which water enters, in inches, per hour..........	96	144	Slow, not measured.	51	65	90	51	Slow, not measured.	Slow, not measured.
Diameter of circle yielding 7,000,000 daily at above rate.	79 ft.	65 ft.		108 ft.	96 ft.	77 ft.	108 feet		

Infiltration galleries have been constructed since about sixty years ago, although there are but few notable examples in this country, those at Columbus, Lowell and Taunton being the most important. There are many examples, however, in Europe where the use of spring or ground water is fast increasing. Thus, in eighty towns of Germany, German Austria and Switzerland, the increase from 1858 to 1876 in the number of inhabitants supplied with filtered and unfiltered river water was 673,000, while the increase during the same period in the number supplied with spring and ground water was over three and one-quarter millions.

The following table exhibits some of the statistics of infiltration galleries in the United States :

STATISTICS OF AMERICAN GALLERIES.

CITY.	Population.	Works built.	Dimensions of Gallery.	Daily Infiltration.	Character of Earth along Line of Gallery.	Proximate Source of Supply.	Dist. of Gallery from River and material interv'g	Cost.	Authority.
Columbus.	70,000	79-83	Inside Diameter, 42 in. Length, 7,580 ft......	5,000,000	Sand and Gravel, with intervals of Clay....	Probably None from the River............	..... Clay and Gravel...	$6.00 to 16.00 per ft.	Wesley Royce, Supt.
Lowell....	70,000	1871	8 ft. wide; 1,300 ft. long	1,125,000	Gravel	Mostly from Landside	100ft Gravel.....	$119,099.72	H. G. Holden, Supt.
Taunton...	21,000	76-84	4 ft. by 5 ft. 2 in.......	Minim'm 800,000	Gravel, with intervals of Clay.............	Two-thirds from Land side	40ft Compact Earth....	....	W. R. Billings, Clerk.
Brookline.	9,000	1874	4 ft. wide; 1,000 ft. long	800,000 to 2,000,000	Gravel and Sand......	Very little from River.	100 to 1000 ft. Gravel and Sand	$6.00 to 12.00 per ft.	F. F. Forbes, Supt.
Woburn...	1,200	1873	12 by 82 ft	800,000	Coarse Gravel.........	Nearly all from Land.	100ft Coarse Gravel ..	....	G. A. Bean, Clerk.

QUALITY.

It is not perhaps too much to say of the ground waters along the line of the gallery, that they are characterized by an exquisite purity.

The surface of the drainage area is almost absolutely free from objectionable features.

The population is very limited, and not likely to increase.

There are no manufactories or other sources of gross pollution present, and none are likely to be found in the future.

A large proportion of the water entering the gallery will have traversed long reaches of sand and gravel strata, the effect of which is, as has been shown by Piefke in Die Boden Filtration, Berlin, 1883, that the organic matter is *gradually destroyed*, owing to the action of the dissolved oxygen.*

The hardness of the water will be substantially the same as that now furnished from Carrier and Coldbrook Creeks, possibly a trifle harder.

Water from a number of the test wells and from Mr. Briggs' spring has been examined by Hugo Thum, Ph. C., of this city, with the following results:

NUMBER OF WELL.	Hardness.		Sulph. Lime, Gr. per Gal.	Iron as Ferrous Oxide Gr. per gal.	Ammonia. Pts. per mill.	
	Permanent.	Temporary.			Free.	Alb.
Six	10.2°	5.8°	1.76	0.14		
Seven	10.6°	7.1°		0.14		
Two					.033	.082
One						.08
Five†					.047	.159
Briggs' Spring					Trace.	.044

There is nothing in these results, and I know of nothing outside of them, to indicate the presence of anything that would detract from the value of the water for domestic use except its hardness, which is a characteristic feature of the ground water of this state.

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* Nichols on Filtration of Saline Solutions Through Sand.

† This sample was very turbid from marl and clay in the pit.

The free ammonia indicates the measure of a gaseous product, resulting from a previous decomposition of organic matter, while the albuminoid ammonia indicates the amount of undecomposed organic matter. The quantity indicated by the analysis is very small, especially that from the Briggs' spring, which I regard as a more representative sample than the others, which were collected from the pits while the work of excavating was in progress. And of the very small quantity of organic matter present, it must be substantially all of vegetable origin.

In the selection of a water for domestic supply, the two following principles have been laid down as fundamental guides:

1. A water suitable for domestic supply must be free from all substances which are *known* to produce an injurious effect on the human system, or which are suspected with good reason, or on good authority, to produce such an effect.

2. The water should be, as far as practicable, free from all substances and from all associations which offend the general æsthetic sense of the community, and thus effect the system through the imagination, even when there is good reason to suppose that it is in itself perfectly harmless.*

The water which will be derived from the proposed gallery will, so far as I can judge, fully satisfy the requirements here laid down by Prof. Nichols.

I think it will go even further.

Its history, the fact of its being derived from clean sandy surfaces free from objectionable features, of its having slowly filtered through vast sheets of pure sand and gravel, the fact of the impossibility of its contamination, its exquisitely clear, colorless and sparkling appearance, and its cool and equable temperature, all combine to give it a value that would be difficult to overestimate.

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* Nichols—Water Supply, Chemical and Sanitary, N. Y., 1883.

It is proper, perhaps, that I should extend this inquiry still further; to examine into the probable financial results that would follow the introduction of water that would by its quality command the respect of the consumer, ignoring the more important sanitary question; to present the best method of procedure, should the works be built, and to inquire as to the total population that could be amply supplied with the 7,000,000 gallons per day, that there is reason to believe can be procured from the construction of the complete gallery. Undoubtedly the introduction of a pure and sparkling spring water would be followed by an immediate increase in the number of water consumers, and a corresponding increase in revenue; and as this would apparently involve a corresponding increase in the consumption of water, it might be at once inferred that the quantity above mentioned was quite too small even for the necessities of our present population, especially in view of the fact that the present consumption—or more properly the pumping—has lately been very near 8,000,000 gallons per day, with the number of services connecting with the works not one-quarter what the present population of the city would justify.

What, then, is a legitimate use of public water? What is ample use, what quantity per capita does a city population require for all purposes, domestic, manufacturing, ornamental, sanitary and municipal? This is a question of importance.

There are $225,000,000 invested in water works in this country, and of the vast quantity of water daily furnished by these works it is an undisputed fact that more than one-half is utterly wasted, without having subserved the slightest useful purpose. Enormous engines are built, pipes laid, additional supplies sought, and vast sums of money thus expended because of this great and growing evil.

In Vienna and Berlin, the daily allowance per capita is fifteen or eighteen gallons; in St. Petersburg it is twenty-two gallons; in Paris, where large amounts are used in washing streets, there are used daily per capita forty-two gallons. In the principal cities of Great Britain the daily supply averages thirty-five to forty gallons, and in London the daily supply is thirty-seven and one-half gallons.

Chief Engineer Ludlow, of the Philadelphia works, estimates that for all purposes for which water may be legitimately used, an ample supply would be as follows :

For domestic purposes	20	gallons.
" manufacturing	15	"
" sprinkling streets, etc	2	"
" fountains	2	"
" fire purposes	1	"
Total	40	gallons.

The actual amount pumped per head in the principal cities of the United States is shown in the following table, computed from "Croes' Statistical Tables," issued January, 1888. All cities are included in the order of their population, and every city of over 42,000 population in 1880 is included. The daily consumption is made up from the census of 1880, and the average daily consumption, which occurred generally in 1882, so that the results will be a trifle too great, owing to the increase in population between these two years.

Table showing approximate daily consumption of water per capita in American cities in 1882, also approximate annual revenue per capita.

CITY.	Consumpt'n	Revenue.	CITY.	Consumpt'n	Revenue.
New York.........	88	$1 36	Toronto...........	78	$2 43
Philadelphia.......	79	1 79	Allegheny..........	127	2 13
Brooklyn...........	61	2 09	Indianapolis.......	53	94
Chicago............	131	2 26	Richmond.....	88	1 30
*a*Boston...........	*a*89	*d*4 27	New Haven.......	95	2 15
St. Louis...........	78	*.....	Quebec...........	48	1 44
Baltimore..........	80	2 03	Lowell............	44	2 36
*b*Cincinnati.........	66	1 99	Worcester.........	56	1 58
San Francisco......	59	5 56	Troy..............	61	1 40
New Orleans.......	42	46	Kansas City......	62	*.....
Cleveland..........	77	1 57	Cambridge........	47	3 36
Washington........	166	72	Syracuse..........	91	1 37
Pittsburgh..........	102	1 92	Columbus.........	51	1 05
Buffalo........	141	2 33	Paterson..........	117	*.....
Montreal...........	81	2 94	Toledo............	67	74
Newark............	71	1 63	Charleston........	5	*.....
Louisville..........	69	1 75	Fall River.........	*c*38.07	2 35
Jersey City.........	134	3 59	Scranton..........	102	*.....
Detroit.............	148	2 29	Minneapolis.......	64	64
Milwaukee.........	127	1 44	Nashville.........	92	1 47
Providence.........	35	2 56	Reading..........	Unknown	1 58
Albany.............	Unknown	*.....	Wilmington.......	110	1 86
Rochester..........	47	84	Hartford..........	119	3 16

a 1884. *b* 1883. *c* Each actual consumer in 1883. *d* Sudbury and Cochituate, 1883.
* No returns.

There are but two of the large cities in this list, Providence and Fall River, that show a legitimate use of water, while others indicate that one-half, two-thirds and three-quarters of the water pumped is run to waste. Aside from differences which might arise from purely local causes, I think there is one word that expresses the reason for these results, and that is—administration; not necessarily current administration, but the results of all administration dating from the time when the first work of construction was commenced.

The Boston Water Board, in their report of 1884, referring to the results at Providence, say that it is "perhaps the only city in the United States which has undertaken to manage its water interests with the same reference to business principles that prevails among business men everywhere. We predict that all the large towns and cities will be compelled to follow her example in the near future."

The effect of waste can be readily imagined, its far-reaching evils need but to be suggested; unchecked, it calls not only for the capitalization of vast sums of money, but a daily, hourly, demand upon the public funds for means for maintaining the furnace fires.

Mr. Thos. J. Whitman, of the St. Louis works, said a few years ago, that it cost that city fully $80,000 annually in fuel alone to supply the waste.

The Cincinnati Water Works, during 1882 and 1883, by a system of inspection aided by the Bell Waterphone, reduced the consumption of water from eighty-seven gallons per capita to sixty-six gallons, and, in spite of the increase in population, the fuel account in 1883 was reduced over $20,000 from that of 1881.

The Chief Engineer of the Boston Water Board, in the report of 1884, says, in speaking of the very satisfactory methods in operation in that city to prevent waste, "there is no question but the consumption can be easily reduced to sixty gallons per head." In the same report the board also say that unless Boston can keep the consumption down to sixty gallons, the taxpayers will be compelled, at a very early day, to expend millions of dollars for a new source of supply.

Comparatively inexpensive methods of restricting and preventing waste are now well known, and in successful and eminently satisfactory operation; methods that work no injury to the individual consumer, and deprive him of no useful privilege.

I feel confident that this city may be supplied for many years with water that shall be so acceptable as to invite its general use, without having the average daily consumption exceed sixty gallons per capita.

The 7,000,000 gallons derived from the gallery would, therefore, satisfy the complete demands of a population of 116,000 individuals.

I think the immediate construction of the entire gallery as designed would not be advisable. I think the best policy will be found in the construction at first of about one-third of it, or sufficient to yield say three or four million gallons per day. This would not involve an outlay probably exceeding $150,000, and would provide sufficient water for a number of years, during which time there is good reason for believing that the revenue from the works will be so increased as to provide means for the extension of the gallery whenever it becomes necessary. So important is this question of revenue, that I desire to consider it further.

The following table, prepared from Croes' Statistics, shows the annual revenue from water rents of cities in the United States having a population over 25,000 and less than 100,000. The population is from the census of 1880, the revenue was generally that of 1882; seven cities from which no returns were obtained are not included.

ANNUAL REVENUE FROM WATER RATES.

CITY.	Population.	Receipts.	Annual Price Paid per Hydr'nt by City.
Rochester	89,366	$ 75,766 00	0
Allegheny	78,682	168,000 00	0
Indianapolis	75,056	70,940 00	$ 50 00
Richmond	63,600	82,748 00	0
New Haven	62,882	135,331 00	16,000 for all.
Lowell	59,475	140,398 00	0
Worcester	58,291	92,007 00	0
Troy	56,747	79,609 00	0
Cambridge	52,669	180,485 23*	10 00 599†
Syracuse	51,792	71,090 00	26,000 for all.
Columbus	51,647	54,700 00	0
Toledo	50,137	37,394 00	0
Fall River	48.961	115,301 00	0
Minneapolis	46,887	30,000 00	0
Nashville	43,350	64,000 00	(?)
Reading	43,278	68,481 00	0
Wilmington	42.478	79,035 00	0
Hartford	42,015	132,882 00	30 00 391†
Camden	41,659	65,644 00	(?)
Lawrence	39,151	78,111 00	40 00
Dayton	38,678	23,214 00	0
Lynn	38,274	93,280 00	(?)
Atlanta	37,409	27,414 00	0
Oakland	34,555	202,933 00	0
Portland	33,819	110,000 00	(?)
Memphis	33,592	60,000 00	0
Springfield (Mass.)	33,340	76,137 00	(?)
Manchester	32,630	67,500 00	60 00 339†
Grand Rapids	32,016	20,238 00	0
Harrisburg	30,762	50,000 00	
Wheeling	30,737	52,022 00	
Savannah	30,709	35,000 00	0
Trenton	29,910	47,875 00	0
Covington	29,720	25,000 00	0
Evansville	29,280	39,689 00	11,130 for all.
Peoria	29,259	24,805 00	0
Erie	27,737	43,819 00	0
Bridgeport	27,643	49,000 00	7,500 for all.
Salem	27,563	53,512 00	0
Ft. Wayne	26,880	10,002 00	0
New Bedford	26,845	46,766 00	12,000
Terre Haute	26,042	30,123 00	40 00 339†
Lancaster	25,769	38,000 00	0

* In 1883.

† Number of hydrants.

From this table it appears that the income from water in Grand Rapids in 1882 was less than that from any works in the

United States supplying more than a city of 25,000 population, with the single exception of Ft. Wayne.

I know of but one reason for the small revenue which is now derived here, after a practical operation of ten years, and that is found in the unsatisfactory quality of the water furnished. The effect upon the financial results of the works may be briefly stated.

Up to May 1, 1884, the receipts from rents since the inauguration of the works exceeded the operating expenses only	$ 33,357 68
The interest account to same date was - - -	286,117 73
Leaving a gross deficiency of - - - -	$252,760 05

which has been made good by a direct tax, equal since the commencement of the works, to about $85.00 per day. The deficiency at present is about $65.00 per day.

This is not what is expected from investments in water works. It is to be expected that the income from works shall pay all current expenses, all interest accounts, and much more; this is a common experience. If any conclusion is possible from the experience of other cities of the size of this, as shown in the foregoing table, it is, that with a desirable water the revenue of this city with the present population ought to be at least $50,000 annually. That means that the investment represented by the bonded indebtedness should be a paying one, just as much as are investments in any desirable stock.

I wish to urge this point, because many persons seem to regard our water bonds as of necessity a burden to be carried, just as bonds issued for public buildings or bridges are.

I could give many instances illustrating this matter. I will, however, refer to but one, by no means the best or an unusual one, that of Lynn, Mass. The cost of the works is a little over $1,000,000. The average consumption of water per day, 1,560,000 gallons; population, 45,960. The financial showing for 1883 is as follows:

Rents from use of water		$98,893 54
Interest account for 1883	$55,436 87	
Maintenance and operation	21,456 14	
Surplus for sinking fund or extension of works	22,000 53	
		$98,893 54*

Perhaps a fair statement, going to show what may be reasonably expected in the way of an increase in revenue following the introduction of an improved water, may be found in the experience of Columbus. The water originally provided to the works gradually became undesirable; in 1877 the first section of the infiltration gallery was built, and pure spring water introduced. At that time the annual revenue was less than it was three years before, but during the next three years it increased 81 per cent. In 1877 the receipts were $24,548.32, while in 1884 they were $68,446.85, an increase of over $40,000. Still more marked is the net earnings or excess of revenue over operating expenses and repairs. In 1877 the net earnings were less than $2,000; in 1884 they were over $47,000.

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* The rents for 1884 were $113,832.60.

In referring to the influence of the gallery upon the finances of the department the Trustees say, in their report of 1881, "the number of customers is fast increasing, as the great superiority of the hydrant water becomes known. There need be no fears for the future financial success of the works. The good offices of the filtering gallery has already assured this."

I do not for a moment doubt but the investment necessary to introduce the gallery water will not only prove a paying one in itself, but that it will work a complete revolution in the financial condition of the works, and render them in a very few years self-sustaining, a result that must certainly be desired by every citizen.

The advisability of adopting the plan which I have the honor to submit, depends somewhat upon a question which I have not yet discussed. Is there a better way by which the wants of this growing city can be met?

So far as I am able to judge there is not. I have in the past examined with care many proposed plans for water supply for this city, all I think, suggested, that seemed to possess merit, without finding any that was satisfactory in the most important particular; in fact, in the one great overshadowing requirement of a water supply—the quality—present and prospective.

Hence for this reason, if for no other, I take pleasure in recommending the plan now submitted for your consideration.

Even if the cost of the work was very much greater than estimated, it would still be less than any other plan which I have examined. Even if the quantity which I have named could not be reached in practical operation; knowing that ample additional drainage area is within easy reach, I should still have no hesitation in recommending the plan proposed.

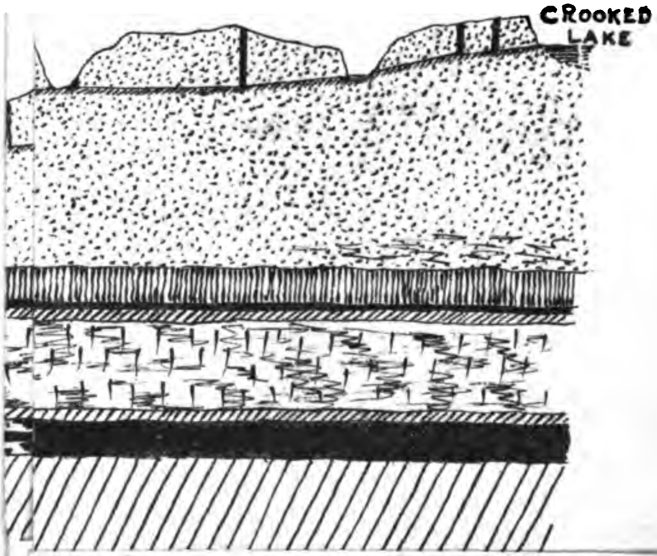
I am indebted to the City Surveyor, Mr. Collar, and his assistants, for valuable services.

To the several members of the board I desire to express my thanks for their cordial support and co-operation.

Respectfully submitted,
A. C. SEKELL,
Civil Engineer.

GRAND RAPIDS, MICH., March 7, 1885.

PLATE. 2.



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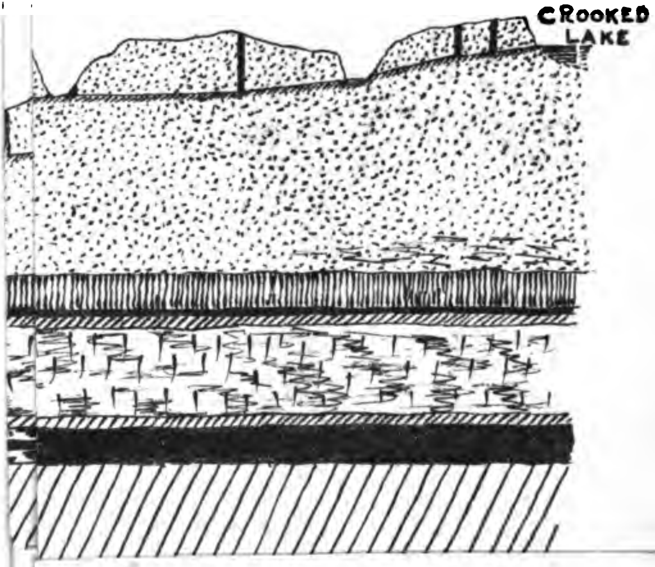

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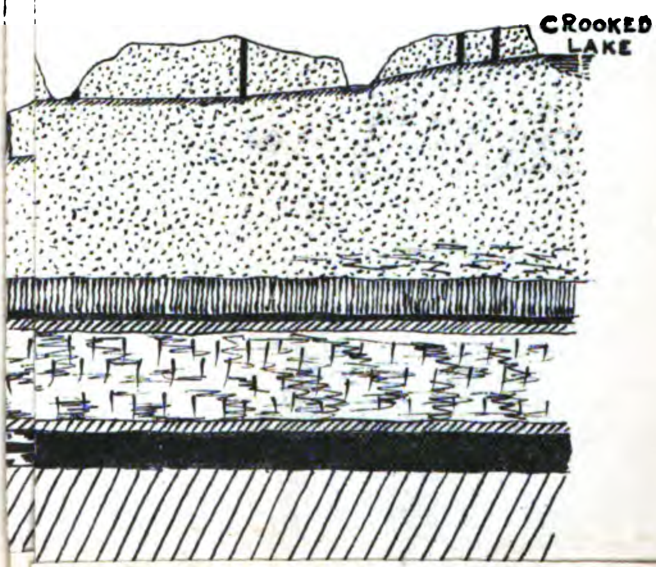
PLATE. 2.



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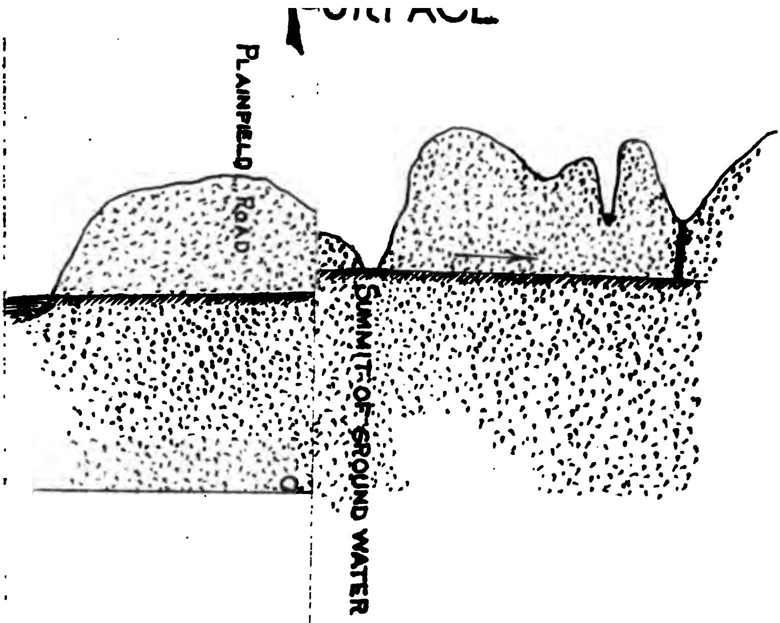

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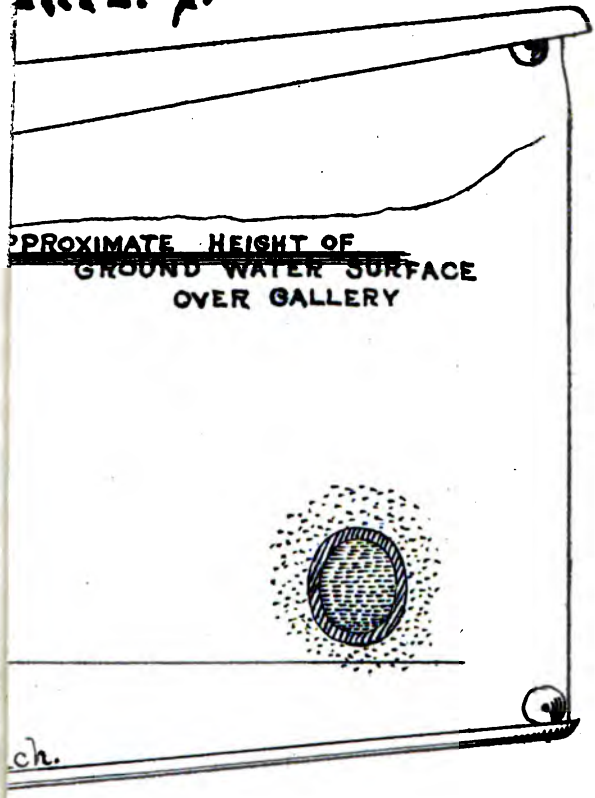
LATE. 4.



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ANNUAL REPORT

—OF THE—

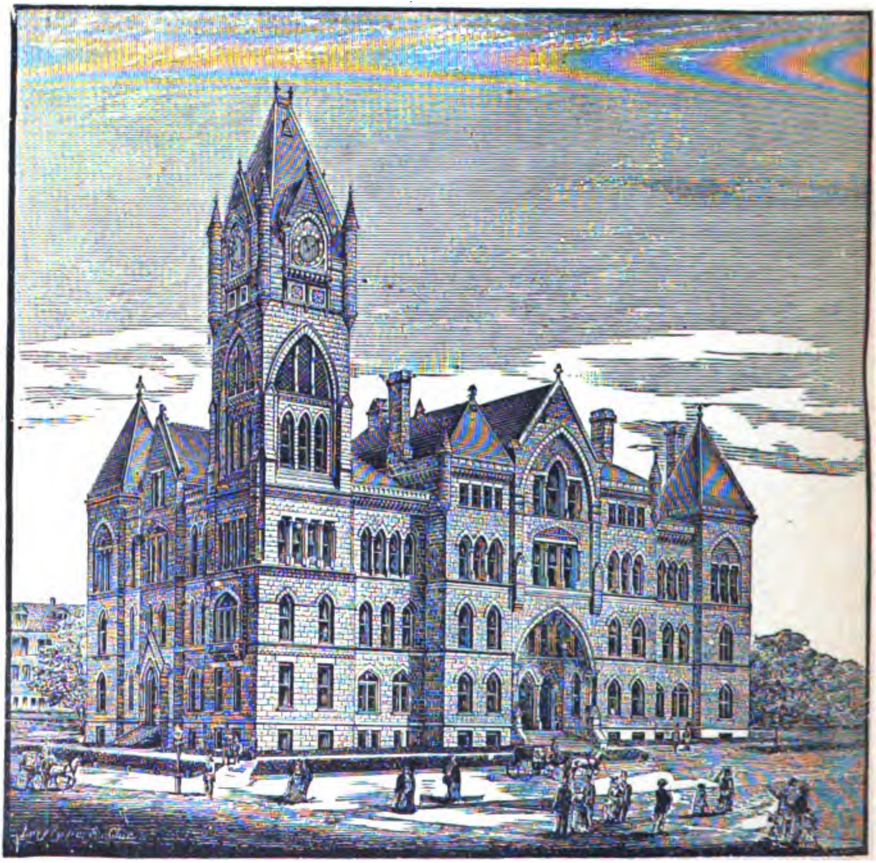
Board of Public Works

—AND—

CITY SURVEYOR,

For the Fiscal Year Ending April 30th, 1885.

GRAND RAPIDS, MICH.:
Eaton, Lyon & Allen Printing Company.
1885.



NEW CITY HALL.

REPORT

OF THE

BOARD OF PUBLIC WORKS

TO THE

Common Council of the City of Grand Rapids,

TRANSMITTING THE REPORTS OF THE

COLLECTOR AND ENGINEER

OF THE WATER WORKS,

FOR THE FISCAL YEAR ENDING APRIL 30, 1885.

ALSO THE ANNUAL REPORT OF THE CITY SURVEYOR.

GRAND RAPIDS, MICH.:
EATON, LYON & ALLEN PRINTING CO.
1885.

BOARD OF PUBLIC WORKS.

GEORGE W. THAYER, President.
(Term Expires May, 1885.)

D. E. EMERY.
(Term Expires May, 1885.)

A. D. PLUMB.
(Term Expires May, 1886.)

WILDER D. STEVENS.
(Term Expires May, 1887.)

GEORGE G. BRIGGS.
(Term Expires May, 1887.)

OFFICERS.

H. A. Collar,	City Surveyor.
Fred A. Twamley,	Clerk and Collector.
Thos. J. Willard,	Assistant Collector.
Geo. E. Kirk,	1st Engineer at Pumping Works.
S. M. Barrows,	2d Engineer at Pumping Works.
George H. Barrows,	Fireman.
Robert Pennell,	Fireman.
John Van Amberg,	Foreman of Repairs.
John Doyle,	Watchman.

REPORT OF THE BOARD.

BOARD OF PUBLIC WORKS,
GRAND RAPIDS, July 16, 1885.

To the Honorable Mayor and Common Council of the City of Grand Rapids:

GENTLEMEN:—The Board of Public Works respectfully submit to your Honorable Body their report for the year ending April 30th, 1885, together with the Annual Report of F. A. Twamley, Collector of Water Rates; of H. A. Collar, City Surveyor, and George E. Kirk, Engineer in charge of the Pumping Works.

The report of the Collector shows that with the growth of the City comes a corresponding increase of water takers, very largely for lawn and street sprinkling purposes; the number would be greatly augmented if the water supplied was unobjectionable for domestic purposes.

The use of meters is being gradually increased with good results in detecting leaks and preventing an unnecessary use of water.

The repairs on the Wyckoff Pipe for the year have been $950.72, against $554.20 for the previous year. The gross receipts for water, for the year, have been $28,676.35, against $24,636.59 for the preceding year; gross expenditures $17,242.72, against $16,873.64. Net income, $11,433.63, against $7,762.95.

The City has 278 fire hydrants for which water is furnished free. If the water works income fund should receive from the City a just compensation for the maintenance of these hydrants and supplying them with water, the present deficit of about $20,000 between the net earnings of the Works and the interest on the outstanding Water Bonds would be nearly, or wholly overcome. The city of Syracuse, N. Y., with a population of about 52,000, shows its receipts from water for one year to be $71,000, of which sum $26,000 is paid by the city for the maintenance and supply of fire hydrants Many other cities pay to their water department, various sums, ranging from ten to seventy-five dollars annually for each hydrant. The laying of a direct tax of $20,000 and upward per annum to pay interest on Water Bonds consequent upon the failure of the Works to earn the interest on the money invested, makes the Water system appear to the public to be burdensome. If this amount, or some adequate specified sum should be annually paid into the income fund for fire protection, the water service, even now, with its limited mains, its insufficient and unsatisfactory supply, would be nearly or quite self-sustaining. While this would not reduce taxation, it would relieve the Water Works from the unjust odium of being supported by a yearly subsidy.

The attention of the Council is particularly invited to this point with a view of securing such action as will permit the Water department to make a showing that it is justly entitled to present.

The report of the Engineer in charge of the Pumping Works indicates a large increase in the pumping service. We are rapidly nearing a point, when at times, both the supply of water, the capacity of the engine, pumps and forcing main will be inadequate to meet the public requirements. The average daily pumping service for the past year has been about seventeen hours; at times, the pumps have been run at their full capacity for the entire twenty-four hours. The water raised into the reservoir during the past year, in excess of the previous year, has been about one hundred and fifty million gallons, or over four hundred thousand gallons per day, at a cost for fuel alone, of over $1,200.

In consequence of the evident waste of water, the Board are about inaugurating means to secure a more strict compliance with its rules and regulations governing water consumers, as it is only by such means that a possible water famine can be averted. No good results from an unnecessary or wasteful use of water; on the contrary, it at times endangers the limited supply, and imposes needless expense.

Since the Board submitted their last Annual Report, much has been done looking to a new and better source of water supply. With the approval of the Council, a two years lease was made on the 15th day of July last with Robert Briggs, securing to the City the right to prospect on his land for water for that length of time, for the sum of $500, with the understanding, that if the City shall, on or before the expiration of said lease, desire to obtain full title to any portion of the lands, said $500 shall be applied as a part of the purchase price. As soon after obtaining the lease as practicable, a number of large test pits were sunk at various points with a view of ascertaining the amount of water that would flow into an infiltration gallery, should the construction of such a gallery be warranted. The results obtained were satisfactory to the Engineer in charge and to the Board, as indicated in their special reports on the subject to the Council, under date of May 9, 1885, in which it was recommended that a special election be ordered by the Council with a view of securing from the taxpayers authority to provide the necessary means to carry into effect the recommendations made by the Board. Such election was ordered, and held on the 7th inst., resulting in a refusal to authorize the Council to provide the means as suggested.

The result of this public expression upon the recommendations of the Board, the causes that led to that result, and the views of the Board as to the action that it may be expedient to take in the future in relation to an additional and better water supply, will be the subject of a special communication to your Honorable Body to be hereafter presented.

The report of the City Surveyor, herewith submitted, gives a full statement of the public work carried on during the past year under the direction of the Board, covering the establishing of street grades, the grading, graveling and paving of streets, the construction of sewers, the erection of bridges, laying of water mains, etc.

The total cost of all these improvements for the year aggregates $197,022.31, against $108,517.76 for the previous year. The Fulton street bridge has been fully completed within the year; this bridge is regarded by the Board as one of the best specimens of public work of its class to be found in the State—an opinion that appears to be largely shared by the public.

Early in the year, the attention of the Board was directed to the preliminary work necessary, preparatory to procuring plans for a new City Hall. After much careful consideration, a plan was approved in October last; the contract for the construction of the building was made on the 9th of April for $185,641.68, to W. D. Richardson, of Springfield, Ill. The work is now progressing in a satisfactory manner. It is expected that the building will be placed under roof before winter. It is believed that, when this building shall be fully completed, it will be a just source of pride and satisfaction to our citizens generally. As the report of the Surveyor gives quite a full description of the structure, there is no occasion to make further reference to it here.

It gives the Board pleasure to say, that the duties devolving upon the Surveyor, Collector of Water Rates, the Engineer in charge of the Pumping Works, and their several assistants, have been performed in a highly satisfactory manner.

Respectfully submitted,

GEORGE W. THAYER,
WILDER D. STEVENS,
A. D. PLUMB,
GEORGE G. BRIGGS,
D. E. EMERY,
Board of Public Works.

COLLECTOR'S REPORT.

OFFICE OF BOARD OF PUBLIC WORKS,
Grand Rapids, May 1, 1885.

To the Honorable Board of Public Works:

GENTLEMEN:—I respectfully present the following report for the year ending April 30, 1885:

The number of services on the 1st of May, 1884, for which permits were issued were	1,247
Taps granted without permits	25
Private mains connected with Works	35
Total	1,307
Number of services put in the past year for which permits were issued	145
Taps granted without permits	2
Private mains connected with works	2
Total number of connections on May 1, 1885	1,456
Number of services now cut off	137
Number of services now open	1,319

The receipts at this office for the year have been as follows:

From water rates, fines, etc	$ 27,850 35
From water permits	826 00
Total income from Water Works	$ 28,676 35
There has also been received from labor and sale of material	98 51
From sale of house on City Hall lot	500 00
From sewer permits	159 00
From contractor's forfeit on bid	25 00
Total receipts for the year	$ 29,458 86
Cash on hand May 1, 1885	501 27
	$ 29,960 13

Deposits have been made with the City Treasurer during the year as follows:

To the credit of Water Works income fund	$ 28,885 91
To the credit of City Hall fund	500 00
To the credit of general fund	25 00
To the credit of first district sewer fund	121 50
To the credit of second district sewer fund	37 50
To the credit of Fulton street bridge fund	28 51
Total deposits during the year	$ 29,598 42
Cash on hand to balance	361 71
	$ 29,960 13

Receipts from May 1, 1874—the commencement of collections—to May 1, 1884:

From water rates	$138,300 65
From water permits	6,980 23
From sewer permits	892 50
From various sources (as per past reports)	2,358 91
Total	$148,532 29
Receipts for the past year	29,458 86
Total receipts to date	$177,991 15

Deposits made from May 1, 1874, to May 1, 1884:

To the credit of water works income fund	$145,647 12
To the credit of water works fund	1,193 40
To the credit of first district sewer fund	526 50
To the credit of second district sewer fund	177 00
To the credit of various funds (as per past reports)	487 00
Total	$148,031 02
Deposits made the past year	29,598 42
Cash on hand to balance	361 71
Total	$177,991 15

STATEMENT OF EXPENDITURES.

May 1, 1884, to May 1, 1885

CONSTRUCTION OF WATER WORKS.

1.—Pipe System.

Extensions, etc	$ 3,623 98

2.—Additional Supply.

Experimental Tests	$ 3,047 06

3.-Meters.

New meters and setting	$ 1,046 15
Total paid on construction	7,717 19
Paid previous to May 1, 1884	456,890 86
Cost of Works to date	$464,608 05

Maintenance and Operation of Water Works.

1.—Pumping.

Salary Engineer	$ 1,200 00
Salary Assistant Engineer	780 00
Salary First Fireman	600 00
Salary Second Fireman	550 00
Fuel	6,015 82
Repairs to pumping machinery	161 22
Repairs to boilers and arches	43 65
Repairs to Engine House	44 60
Supplies (oil, packing, etc.)	262 62
	$ 9,657 91

2.—Office and Collecting.

Salary Collector	$ 750 00
Salary Assistant Collector	500 00
Stamps and printing	48 50
	$ 1,298 50

3.—Superintendence and Repairs.

Salary Foreman of Repairs	$ 999 96

1.--Iron Pipe.

Labor	$ 246 86	
Material	18 33	
		265 19

Amount forward		$ 1,265 15
2.—WYCKOFF PIPE.		
Labor	$ 894 44	
Material	56 28	
		950 72
3.—RIVER PIPE, MASON ST.		
Labor	$ 470 53	
Material	46 14	
		516 67
4.—PUMP LOGS.		
Labor		136 01
5.—VALVES.		
Labor	$ 88 87	
Material	280 39	
		369 26
6.—HYDRANTS.		
Labor	$ 495 82	
Material	515 54	
		1,011 36
7.—METERS.		
Labor	$ 369 50	
Material	181 15	
		550 65
8.—SETTLING BASIN.		
Labor		28 75
9.—SUPPLY CREEKS.		
Labor	$ 100 39	
Salary Watchman	239 50	
		339 89
10.—SERVICE CONNECTIONS.		
Labor	$ 108 55	
Material	339 31	
		447 86
11.—MISCELLANEOUS.		
Tools	$ 237 02	
Blowing off	17 50	
Barn	365 13	
Shop	50 34	
		669 99
		$ 6,286 31

RECAPITULATION.

Pumping	$ 9,657 91
Office and Collecting	1,298 50
Superintendence and Repairs	6,286 31
Total paid for maintenance and operation	$ 17,242 72

Income for the year	$ 28,676 35
Cost of maintenance and operation	17,242 72
Excess of receipts over expenditures	$ 11,433 63

METERS.

Seventy-four meters have been added during the year, the total number now owned by the city being 435, of which there are set and in operation 350 of the following manufactures:

Ball & Fitts Rotary	175
Worthington	26
Crown	87
Ball & Fitts Piston	62
	350

There are in the shop the following meters:

Ball & Fitts Rotary	30
Worthington	34
Crown	4
Ball & Fitts Piston	17
Total	85

There is in use one Undine, which is running on trial.

There are in use two Rotary, new style.

Leaks on Distribution Mains

The following table shows the number, cause and location of the various leaks on the mains during the year:

NAME OF STREET.	KIND OF PIPE.	INCH.	MONTH	DAY.	CAUSE.
Kent	Wyckoff	6	May	3	Joint.
Coldbrook	"	20	"	9	"
West Bridge	"	12	"	12	"
Scribner	"	8	"	26	"
Coldbrook	"	16	July	4	"
South Division	"	12	"	5	"
North Canal	"	16	"	14	"
Bronson	"	14	"	21	"
Mason	"	16	"	23	"
Mason	"	16	"	28	"
Ottawa	"	16	August	4	"
Campau alley	"	4	"	6	"
Mason	"	12	"	7	"
Ottawa	"	16	"	11	"
East Fulton	"	10	"	13	"
North Division	"	12	"	15	"
Summer	"	6	"	16	"
West Bridge	"	12	"	18	"
Bronson	Pump Log	6	"	20	Split
Broadway	Wyckoff	12	"	25	Joint
Winter	Iron	12	"	27	"
Ottawa	Wyckoff	16	"	29	"
Mason	"	16	Septemb'r	1	"
Campau alley	"	4	"	17	"
Front	"	4	"	20	Knothole
Fifth	"	6	"	25	Joint
Ottawa	"	16	"	26	"
Fountain	Pump Log	6	"	30	"
Fountain	"	6	October	1	"
Prescott	"	8	"	6	"
Fulton	Wyckoff	10	"	9	"
Fountain	Pump Log	6	"	10	"

Leaks on Distribution Mains--Continued.

NAME OF STREET.	KIND OF PIPE.	INCH.	MONTH.	DAY.	CAUSE.
Coldbrook	Iron	20	October	13	Joint
Coldbrook	"	20	"	15	"
Ottawa	Wyckoff	16	"	17	"
Scribner	"	8	"	21	"
Ransom	Iron	2	"	29	"
North Canal	Wyckoff	8	November	4	"
Buchanan	Iron	8	"	15	"
Fountain	Pump Log	6	"	17	Split
Ottawa	Wyckoff	16	"	20	Joint
Campau alley	"	4	"	22	Split
South Division	Iron	8	"	28	Joint
Coit avenue	Pump Log	6	December	17	Knothole
South Front	Wyckoff	6	"	23	Joint
Scribner	"	6	January	5	"
West Bridge	Wyckoff	12	"	7	"
Mason	"	16	"	14	"
Lyon	"	6	"	30	"
West Fulton	"	12	February	5	"
Bronson	Pump Log	6	"	9	Split
Ionia	Wyckoff	6	April	8	"
Coldbrook	Iron	20	"	2	Joint
South Division	Wyckoff	12	"	9	"
Coldbrook	Iron	20	"	13	"
Coldbrook	"	20	"	16	"
Ransom	Iron	2	"	16	Split
Canal	"	8	"	20	Burst
North Canal	Wyckoff	16	"	27	Joint

The total length of water mains now laid is 26.63 miles; number of fire hydrants, 278; number of valves, 172.

Respectfully submitted,

FRED A. TWAMLEY,

Collector.

ENGINEER'S REPORT.

To the Honorable the Board of Public Works of the City of Grand Rapids :

GENTLEMEN :—I have the honor to submit herewith my annual report of the work done by the pumping engines for the year ending April 30, 1885:

There has been a noticeable increase in the amount of water pumped this year, owing, in part, to the increased number of water takers, and to the severe weather of the past winter.

The engines have performed their work without any stops, and with but little or no repairs.

I would respectfully call the attention of the Board to the necessity of having an instrument that will measure the height of water in the reservoir at the pump house, as it is becoming important that the men at the pump house should know at all times the height of water, in order to keep it more uniform.

The average daily consumption for the year has been 1,937,994 gallons, against an average the previous year of 1,533,781 gallons.

The total cost to pump one million gallons of water into reservoir, $13.59 5-100.

Total cost of fuel to pump one million gallons of water into reservoir, $8.04 1-100.

The running expenses for the year have been:

For Repairs	$ 205 46
For Supplies	280 54
For Wood	6,000 99
For Salaries	3,130 00
Total	$9,616 99

The following table shows the number of days run for each month, the number of revolutions made, gallons of water pumped, amount of wood burned, and cost of the same.

MONTH.	DAYS RUN.	TIME RUN. H.	TIME RUN. M.	NO. OF REVOLUTIONS	GALLONS OF WATER PUMPED.	CORDS OF WOOD USED.	COST OF WOOD USED.
May	31	519	55	605,620	60,562,000	284	$478 10
June	30	423	50	513,999	51,399,900	220	384 10
July	31	439	35	537,192	53,719,200	223	437 00
August	31	422	30	518,082	51,808,200	202½	405 00
September	30	450	45	563,818	56,381,800	224	457 50
October	31	423	30	516,280	51,628,000	233	415 25
November	30	433	00	524,846	52,484,600	221½	402 50
December	31	486	55	583,740	58,374,000	256	504 00
January	31	572	45	681,525	68,152,500	313	594 25
February	28	652	35	694,844	69,484,400	298	582 25
March	31	571	50	727,280	72,728,000	325	574 00
April	30	476	15	606,555	60,655,500	259½	454 12
Total	365	5,873	25	7,073,681	707,368,100	3059½	$5,688 10

Respectfully submitted.

GEORGE E. KIRK,
Engineer.

CITY SURVEYOR'S REPORT.

CITY SURVEYOR'S OFFICE,
Grand Rapids, Mich., May 1, 1885.

To the Honorable Mayor and Common Council:

GENTLEMEN:—I have the honor to submit herewith a report of the public improvements conducted by the Board of Public Works, during the year ending April 30, 1885, together with other matters of interest.

STREETS.

Since 1882, the time when the last statement showing the mileage of streets was published, there has been an increase—results of street openings and plattings—of 7.85 miles.

The total length of streets in the city at present is 140.82 miles, of which there are—

Graded and paved with wood	0.20	miles.
Graded and paved with wood and stone	5.03	"
Graded and paved with stone	1.49	"
Graded, graveled and gutters paved	33.15	"
Graded and graveled	33.11	"
Graded	4.69	"
Unimproved	63.15	"
Total	140.82	"

During the year, grades have been established on twenty-nine streets, as shown by the following table:

Thirty-three estimates of cost for improving the streets mentioned, and for other work, have been prepared and submitted to your Honorable Body.

Table showing the streets on which grades have been approved and adopted, giving their lengths and termini:

STREET.	FROM	TO	LENGTH. FEET.
Barclay	East Bridge	Fountain	1,739
Bowery	South Pine	West Division	2,897
Campau	Pearl	Louis	277
Chatham	Marion	West Division	3,230
Clinton	Mason	Walbridge	882
Delony	Peaslee	Veto	1,584
East Bridge	North Lafayette	East City Limits	3,332
Grove	Plainfield	Taylor	731
Grandville	Prescott	South City Limits	5,031
Indiana	Butterworth	Shawmut	2,558
Jefferson avenue	Cherry	Maple	468
Livingston	Reservoir	Walbridge	417
Logan	South Lafayette	Madison	720
Marion	West Bridge	Jackson	939
North	Alpine	G. R. & I. R. R	1,300
N. Union	East Fulton	D. G. H. & M. R'y	3,518
Oakes	South Division	South Spring	285
Park	North Division	Ransom	730
S. Union	Fifth	Wealthy	2,569
Thomas	Henry	South Union	600
Terrace	Fifth	Wealthy	2,569
Walbridge	Canal	Coit	1,940
West Bridge	Broadway	Gold	1,334
Sycamore	South Division	South Lafayette	1,495
King	Grandville	West	639
Buchanan	Wealthy	Prescott	594
Barnett	North College	North avenue	600
Miller	South Ionia	Buchanan	594
Fairbanks	Clinton	North	2,000

The following table shows the number, name, manner and cost of street improvements completed during the year:

STREET IMPROVEMENTS COMPLETED DURING THE YEAR ENDING APRIL 30, 1885.

NAME OF STREET	FROM	TO	KIND OF IMPROVEMENT.	Length in Feet.	Contract Price.	Est. Incidentals.	Total Cost.	Per Foot	CONTRACTOR.
Second ave	S. Division	Grandville	Graded, graveled, gutters paved	2,322	$ 4,994 00	$ 276 00	$ 5,270 00	$2 22	Grady & Gorman
Page st	Plainfield	North Ave	" " " "	1,738	3,970 00	240 00	4,210 00	2 42	B. Livingston.
James st	Cherry st	Wealthy Ave	" " " "	1,320	4,607 00	113 00	4,720 00	3 60	C. Utes.
N. Front st	W. Bridge	N. end of st	" " " "	7.167	14,440 00	460 00	14,900 00	2 08	A. Wissman.
Monroe st	Spring st	Pearl st	Repaving with wood and stone	....	3,928 25	171 75	4,100 00	......	Prange & Mathewson.
Canal st	Pearl st	Bridge st	" " " "	....	4,625 00	375 00	5,000 00	......	Prange & Mathewson.
Pearl st	W. line Canal	E. line Monroe	" " " "	....	721 00	69 00	790 00	......	Prange & Mathewson.
N. Division	Monroe st	Lyon st	Repaving with wood	....	1,974 00	226 00	2,200 00	......	A. C. Sekell.
Coldbrook st	Canal	E. line Taylor	Repair roadbed with wood and stone	....	1,574 00	106 00	1,680 00	......	A. C. Sekell.
Grandville ave	Summit	Prescott	Grade, gravel and gutters paved	1,437	4,000 00	140 00	4,140 00	2 88	C. Utes.
Campan	Pearl st	Louis st	Graded, paved with wood and stone	277	1,089 00	71 00	1,160 00	4 15	J. Collins.
Cass	Morrison	Fifth Ave	Graded, graveled and gutters paved	3,214	4,960 00	340 00	5,300 00	1 65	Kloote& D'Bruin
Grove	Taylor	Plainfield	" " " "	731	1,347 00	133 00	1,480 00	2 02	L. Schneider.
Alley, blk 13, Bostwick & Co.	Sheldon	Lagrave	Graded	270	23 00	....	23 00	......	A. Rens.
Bowery	S. Pine	W. Division	Graded and graveled	2,897	4,950 00	140 00	5,090 00	1 73	B. Livingston.
Lagrave	Maple	Blakeley Ave	Graded, graveled and gutters paved	1,819	3,995 00	205 00	4,200 00	2 30	A. Wissmann.
Jefferson ave	Cherry	Maple	Graded, paved with wood and stone	466	2,100 00	100 00	2,200 00	4 72	J. Collins.
Fountain	Ottawa	Division	" " " " "	523	2,493 00	127 00	2,620 00	5 00	C. Prange.
Park	Ransom	Division	Graded, graveled and gutters paved	730	2,387 00	113 00	2,500 00	3 42	A. Rens.
W. Park Place	Park	Monroe	" " " "	352	960 00	60 00	1,020 00	2 90	L. Schneider.

SEWERS.

The system of sewerage now constructed has a total length of 33.705 miles, as shown by the following:

Brick Sewers	15.698	miles.
Glazed Pipe Sewers	15.514	"
Cement Pipe "	.480	"
Wood "	1.853	"
Iron Pipe in river	.160	"
Total	33.705	miles.

The sewers completed during the year, together with those now under contract, are shown by the following tables:

SEWERS COMPLETED DURING THE YEAR ENDING APRIL 30, 1885.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man-holes.	Catch Basins.	Length in feet.	Contract Price.	Est. Incidentals.	Total Cost.	Contractors.
Flushing sewer, Canal and Newberry	In Newberry st., from sewer in Kent alley w. to Canal st., thence n. to Comstock's log run	15 in glazed pipe	1	....	244	$ 294 00	$ 46 00	$ 340 00	J. Collins.
Park st	In Park st., from e. line E. Park Place w. to sewer in N. Division st.	12 in. glazed pipe 9 " " "	3	....	378 200	375 00	115 00	490 00	J. Collins.
Bronson st	In Bronson st., from 300 ft. e. of N. College ave. w. to near w. line of N. Prospect st.	12 in. glazed pipe 9 " " "	5	2	885 367	687 00	173 00	860 00	A. Rens
Ransom st	In Ransom st., from 200 ft. s. of Lyon st. s. to sewer in Fountain st.	9 in. glazed pipe	2	....	495	283 00	77 00	360 00	A. Rens.
Lane ave. & Fremont st	In Lane ave., from Sibley st. ditch n. to W. Bridge, e. in W. Bridge st. to Fremont st., n. in Fremont to Fourth st.	28x42 brick 24x36 " 20x30 " 18x27 " 16x24 "	9	8	1636 442 364 366 392	8,500 00	420 00	8,920 00	J. Collins.
W. Leonard and Alpine ave.	In W. Leonard, from Davis to Alpine ave., n. in Alpine to n. city line	24x36 brick 20x30 " 18x27 " 16x24 " 12 in. glazed pipe	5	8	640 647 658 806 515	7,693 00	957 00	8,650 00	C. Prange.
Alley Blocks 11 and 12, Scribner & Turner ad	From 160 ft. s. of Sixth st. n. to sewer in Seventh st.	12 in. glazed pipe 9 " " "	2	...	263 226	240 00	50 00	290 00	J. Collins.
Alabama	In W. Bridge, from sewer in Winter w. to Alabama, thence n. to 50 ft. s. of Third	16x24 brick 12 in. glazed pipe 9 " " "	4	....	185 410 684	1,124 00	156 00	1,280 00	A. C. Sekell.
Cass st	In Cass st., from Morrison st. s. to sewer in Wealthy ave	12 in. glazed pipe	2	2	627	574 00	126 00	700 00	Kloote & DeBruin.

Washington st. sewer extension	In Washington st., from w. line Madison ave. n. on curve to n. line Washington, thence n. e. across private property to College ave. at a point 312.5 ft. n. of Washington st	18x27 brick	2	1	882	$1,982 82	$ 337 18	2,320 00	A. Rens.
Welton alley	From 50 ft. n. of Wealthy ave. in alley bet. Madison ave. and S. Prospect st., n. to sewer across private property	9 in. glazed pipe	1	....	328	139 00	61 00	200 00	Kloote & DeBruin.
Lyon st	In Lyon st., from near w. line Ranson e. to N. Lafayette st	15 in. glazed pipe 12 " " "	3	3	412 400	973 02	166 98	1,140 00	A. Rens.
Alley blk 1, Porter's ad	In said alley, from 50 ft. n. of Wenham ave. n. to sewer in Wealthy ave	9 in. glazed pipe	2	....	503	265 00	75 00	340 00	J. Collins.
Winter st. sewer extension in Broadway	In W. Bridge st., from Winter st. sewer to Broadway st., n. in Broadway st. to n. city line	12 in. glazed pipe 22x33 brick 35x45 " 41x53 " 56x72 "	18	40	1410 1222 1311 1303 2804	25,547 00	1203 00	26,750 00	M'Brian & Farr
Seventh and Davis sts.	In Seventh st., from Broadway sewer w. to Davis, n. in Davis to W. Leonard st	30x45 brick 40x52 " 45x58 "	7	8	1330 1310 1550	15,775 00	725 00	16,500 00	C. Prange.
Wealthy ave sewer ext.	In Wealthy ave., from w. line Cass to S. Lafayette st., thence n. in S. Lafayette to Holland, thence e. in Holland st. to S. Prospect, thence e. through private land to Buckeye, e. in Buckeye to Henry, thence e. through private property to city line	28x42 brick 20x30 " 18x27 " 16x24 " 14x21 "	12	18	410 306 659 2306 709	8,880 00	530 00	9,410 00	J. Collins.
Monroe and Lyon st. outlet sewer	In Canal st., from Pearl st. sewer n. to Lyon w. in Lyon st. to river	24 in. circular, brick 16 in. wr'ght ir. pipe 18 in. circular, brick	7	....	501 350 350	3,865 00	382 00	4,247 00	A. C. Sekell.
Coldbrook st. sewer outlet	From the w. terminus of Coldbrook st. sewer w. into river	8 in. cast iron pipe	...	....	144	150 00	....	150 00	I. B. Mathewson

SEWERS UNDER CONTRACT AND NOT COMPLETED APRIL 30, 1885.

NAME OF STREET.	LOCATION.	SIZE AND KIND.	Man-holes.	Catch Basins.	Length in feet.	Contract Price.	Est. Incidentals.	Total Amount.	Contractors.
First ave.	In First ave. from 160 feet w. of S. Division st. w. to sewer in Buchanan st.	12 in. glazed pipe.. 9 " " " ..	3	5	423 700	$ 725 00	$ 125 00	$ 850 00	Joel Collins.
Second st.	From w. line of Scribner st. w. to sewer in Broadway st.	9 in glazed pipe..	8	1	600	310 00	60 00	370 00	A. Rens.
W. Bridge st.	From e. line of Alabama st. to e. line of Gold st.	16 in. x 24 in. Brick 12 in. glazed pipe..	8		588 330	1,394 00	106 00	1,500 000	Kloote & DeBruin.
Alley, Block 8, Converse & Tolford's Addition	From n. line of Watson st. to sewer in w. Fulton st.	9 in. glazed pipe..	3		797	390 00	50 00	440 00	J. McDermott.
Alley, Block 12, Converse & Tolford's Addition	From n. line Watson st. n, to s. line w. Fulton st. thence easterly on a curve to center of w. Fulton st. 20 feet east of east line of Alley thence e. to e. line of w. Broadway st.	9 in. glazed pipe..	8		597	441 00	49 00	490 00	A. Wissmann.
Third ave.	From Grandville ave. e. to sewer in Buchanan st.	12 in. glazed pipe.. 9 " " " ..	5	8	947 250	708 00	122 00	830 00	L. Schneider.

Since the construction of the Winter street sewer extension in Broadway street, it has been carried on the reports as work uncompleted; settlement on the contract being held in abeyance, awaiting the result of a suit at law. The case was decided at the last session of the Supreme Court.

Settlement with the contractor for the construction of the Seventh and Davis street sewer was not effected until the result of the suit above mentioned was known, when the contractor requested the presentation of his final account.

Both sewers are herein entered as work completed.

OUTLET SEWERS.

The Fulton and Washington street outlet sewer which was completed last year has given very satisfactory results.

Slight repairs were necessary after the heavy rains of last spring.

The Canal and Lyon street intercepting sewer, mentioned in last report, has worked very satisfactorily.

The contract price was	$3,865 00
Rock excavation	311 65
Total	$4,176 65

Without including the cost of the iron pipe used.

The system for outlet sewerage, for which an appropriation of $9,000.00 was made, has cost as follows:

Fulton and Washington street sewer, not including iron pipe	$2,513 81
Canal and Lyon street " " " " "	4,176 65
Wrought iron pipe used in both sewers	1,677 59
Incidentals	224 97
	$8,593 02
Leaving a balance to the credit of the fund	406 98

For the abatement of a nuisance occasioned by the discharge of the Coldbrook street sewer upon the uncovered river bottom during low stages of the water, an arrangement similar in construction and for the same purpose was provided, which conveys the sewage 144 feet away from the shore into rapid running water, through an eight inch cast iron pipe. The work was done by contract and paid from the First District Sewer Fund.

The contract was awarded to I. B. Mathewson, Aug. 16, 1884, for	$150 00
Pipe furnished by City cost	103 20
Making the total cost of the work	$253 20

BRIDGE STREET BRIDGE, PIERS, APPROACHES, ETC.

The Board were of the opinion that to place the floor of the new bridge to be erected at this point, at the same elevation as that of the old one—there being quite one-half the depth of girder beneath the floor—would greatly endanger the structure; they therefore concluded to place the bridge twenty inches higher. The wisdom of such action was clearly demonstrated last winter, when the river was filled by an ice jam to near the lower chord of the bridge.

Aside from the increased security to the bridge, decided benefits arise from another source. Storm water falling upon the approaches is now conducted away from the bridge, where it flowed to, and upon the structure, much to the annoyance of pedestrians.

The bridge contracted for with the Morse Bridge Co. to be erected at this point, has been completed and in use for several months.

Mr. Higgins, contractor for the piers for this bridge, resumed his work as soon as practicable in the spring. The work was carried forward as far as possible before the old bridge was removed; after which, work was continued to completion in advance of the bridge erection.

The increased height of masonry consequent upon raising the bridge, and some incidental work, added materially to the cost of the masonry.

The entire cost of the masonry was $9,913.06.

Changing the grade of the bridge made it necessary to raise the short span at the east end thereof; which work was skillfully performed by Mr. H. H. Ives. It also necessitated regrading the approaches. The pavement on the east approach was taken up for a distance of one hundred feet east of the bridge, filling sufficient to make it conform to the new grade placed therein, and the roadway repaved.

The sides of the embankment of the west approach—from a sense of false economy or indifference—were originally walled up with slabs, which had rotted, settled, and damaged the roadway considerably. To properly reconstruct the approach, it was necessary to remove the slabs, build revetments of stone masonry, fill up and repave the street. Plans for the work were prepared and placed in the hands of Mr. Ebenezer Anderson for execution.

The entire cost of this improvement, itemized, is as follows:

Bridge	$21,800 00
Piers	9,913 06
Approaches	2,031 77
	$33,744 83

FULTON ST. BRIDGE, BRIDGE MASONRY AND APPROACHES.

At a meeting of the Common Council held July 2d, 1883, a resolution was passed declaring the construction of a bridge across the river at Fulton street a public necessity. Subsequent to that time, the street was extended to the river from Waterloo street by taking private property therefor. On the 21st day of April, 1884, another resolution was adopted, citing that Fulton street is now opened and extended, and requesting the Board to proceed with the construction of the bridge as soon as practicable.

Surveys preliminary to the work were made as soon as the water had subsided sufficiently, and the matter then placed before the Board for consideration. It was decided to construct an iron bridge five hundred and forty feet long, consisting of four spans of equal length, and to construct the foundation therefor of bowlder stone. The facing of the abutments and piers is in regular range work of well scabbled stone, and the entire work laid in cement mortar.

The water main lying in the bed of the river at this point was near the line of the up-stream end of the piers. The pipe was laid without reference to the location of a bridge, and was in such a position as to necessitate the placing of the east end of the bridge seven feet north of the point it ought to have occupied, to secure a proper footing for the arch over the pipe on the up-stream side thereof.

The iron sewer pipe which extends to the middle of the river below the piers had to be built over in the same manner as the water main, in the east abutment. Also storm-water outfalls for sewers were made in the south wing walls of each abutment.

The masonry was commenced below the water pipe on a bed of heavy gravel and stones, from two to three feet below the river bed. The average height of the masonry is twenty-five feet.

The contract was awarded July 7, 1884, to John Olson, for $19,400.00. An extension to the south wing wall was necessary because of the changed location of the abutment, increasing the cost of the work to $19,911.25.

As soon as obstructing buildings in the street were removed the contract for grading the approaches to the bridge was awarded. This work included the extension of the East and West Fulton street sewers from their then present terminus to the openings provided in the abutments therefor. The length of the two approaches is 613 feet; the deepest fill, 22 feet. As a protection to the embankment against the action of high water, ice, etc., the slopes were paved with large stone.

The center of the roadway for a width of 16 feet will be of cedar block paving; the gutters to be paved with cobblestone, each 11 feet wide.

This contract was awarded to C. Prange, Aug. 23d, for $8,437.00. Paving the side slopes to be paid for extra at the rate of $1.00 per square yard.

BRIDGE.

The contract for the bridge construction was awarded Dec. 12, 1884, to the Massillon Bridge Co., of Massillon, Ohio, for $20.948.00. It is of the Whipple type, with end posts askew 23°. The length is 540 feet, width of roadway between felloe guards 22 feet, with two side walks each of six feet clear width. The girders are proportioned to to carry 2,720 pounds of rolling load per linear foot, with five as the factor of safety. The floor beams under the roadway are proportioned, to carry 110 pounds per square foot of same, with seven as the safe factor.

CITY HALL.

The contract for building the City Hall was awarded April 9 1885, to W. D. Richardson, of Springfield, Ill., for $185,641.68.

The Hall is located on Lyon street, between North Ionia and Ottawa streets.

The structure is to be a first-class fire-proof building, after plans of E. E. Myers, architect, of Detroit, Mich. It is of the Norman style of architecture, in random range, rock-faced ashler, of Ohio blue stone. Its depth through the central part is 108 feet, by a length 164 feet on the front. Height of the Lyon street or principal front is 96 feet; of the finial on main tower 163 feet.

The three entrances to the first floor are reached by broad flights of granite steps. The arch of the Lyon street or grand entrance is supported by columns of polished red granite, with similar but lighter columns at the doors.

The basement is provided with five entrances. The Engineer's, boiler and fuel rooms, Director of the Poor's supplies, nine other unassigned rooms and three storage vaults are located here. Height of story is nine feet in the clear.

The first or principal floor has a wide corridor extending the entire length of the building, opening upon Ottawa and N. Ionia streets, and from which a corridor extends to the main entrance. This story contains seventeen large office rooms and three vaults. Height of story fourteen feet.

The second story is reached by a broad iron stairway landing in a corridor similar to the long one on the first floor. The Public Library is temporarily provided for on this floor, occupying five large rooms. Thirteen office rooms and two vaults are also upon this floor. The clear height of this story is sixteen feet.

The third story contains the Common Council chamber, Superior Court room, eleven other rooms, and one vault. It is sixteen feet in